MARINE SANTONIAN AND CAMPANIAN OSTRACODS FROM A BOREHOLE AT RICHARDS BAY, ZULULAND

By

R. V. Dingle

Department of Geology, University of Cape Town

(With 33 figures and 4 tables)

[*MS. accepted 20 December 1979*]

ABSTRACT

36 species, representing 17 genera of ostracods are recorded from Santonian and Campanian rocks penetrated by borehole BH–9 near Richards Bay, Zululand. 19 of the species are new, 6 are left in open nomenclature, whilst the remaining 11 species have been previously recorded from Santonian rocks at Umzamba in Transkei. One new genus, *Unicapella*, is erected. The new species are: *Cytherelloidea newtoni, C. griesbachi, C. contorta, Paracypris zululandensis, Bythocypris richardsbayensis, Bairdoppilata andersoni, Amphicytherura zululandensis, Brachycythere sicarius, Unicapella sacsi, U. reticulata, Cythereis klingeri, Haughtonileberis vanhoepeni, Hermanites kennedyi, Oertliella pennata, O. africana, Trachyleberis zululandensis, T. minima, Rayneria nealei*, and *Gibberleberis elongata.*

Population studies reveal five distinctive ostracod assemblages, each dominated by one or two species, that can be related to the following sedimentary environments (dominant taxa in parenthesis). In ascending order these are: 1. shallow, restricted water, high energy (*Brachycythere longicaudata*); 2. shallow, restricted water, low energy (*B. longicaudata* and *Haughtonileberis haughtoni*); 3. shallow, open water, low energy (*Cythereis klingeri*); 4. moderate depth, open water, low energy (*Bairdoppilata andersoni*); 5. deep, open water, low energy (*B. andersoni* and various Cytherellids). Assemblages 1–3 are Santonian in age, whilst 4–5 correspond approximately to Campanian I and II, respectively.

CONTENTS

	PAGE
Introduction	1
Summary of the stratigraphy of borehole BH–9, Richards Bay	3
Systematic descriptions	3
Discussion	60
Palaeoecology	60
Ostracod assemblages 1–5	60
Sedimentary environments	63
Biostratigraphy	67
Acknowledgements	68
References	69

INTRODUCTION

Although Upper Cretaceous sediments occur extensively on the continental shelf round southern Africa, onshore exposures of Santonian and Campanian rocks are confined to small areas along the south-east coast (Dingle 1978). The best exposures occur in the cliffs at Umzamba (Transkei) and round the shores

Ann. S. Afr. Mus. **82** (1), 1980: 1–70, 33 figs, 4 tables.

of False Bay (Zululand), whilst other small outcrops and excavations are known from Igoda (eastern Cape), Itongazi, and Durban. A further locality has recently been provided by a borehole at Richards Bay on the Zululand coast (Maud & Orr 1975) (Fig. 1) where the preservation of fossils is so good that many of the molluscs have retained their original aragonitic mineralogy and nacreous sheen. In a region where deep Tertiary weathering has decalcified many of the natural outcrops, the material from this borehole provides an excellent opportunity to study small and delicate fossils.

Generally speaking, microfossils from the Upper Cretaceous rocks of south-east Africa have received little attention. Ostracods are one group which are poorly documented, with only three publications to date, all dealing with Santonian assemblages from the lower part of the Umzamba section (Chapman 1904, 1923; Dingle 1969). In providing a regionally applicable biostratigraphic framework, the recently completed thorough revision of ammonite taxonomy and zonation by Kennedy & Klinger (1975 et seq.) and Förster (1975) has removed one of the obstacles to further study of the less age-diagnostic micro-

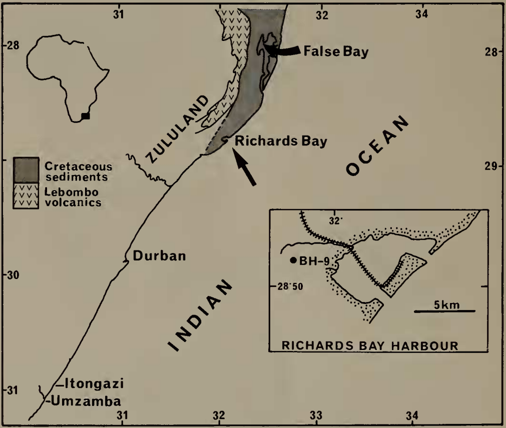

Fig. 1. Location of BH9, Richards Bay, Zululand. Other Santonian-Campanian localities are indicated: Umzamba, Itongazi, Durban, and False Bay.

fossil taxa, and the author is currently undertaking a comprehensive investigation of the Barremian to Maastrichtian ostracod assemblages from south-east Africa. The present paper, in describing material from the well-preserved section in the Richards Bay borehole, will form a stratigraphic and ecologic standard for comparison with the other less complete, and widely scattered Senonian sequences.

SUMMARY OF THE STRATIGRAPHY OF BOREHOLE BH-9, RICHARDS BAY

The borehole is situated 14 km west of Richards Bay township (Fig. 1) (shown as Borehole W by Maud & Orr 1975, fig. 1), and passed through 159 m of Upper Cretaceous sediment before entering granitic basement gneiss. 60 m at the top of the core were weathered and unfossiliferous, and only the section 82 m to 159 m was available for micropalaeontological analysis by the author. Lithologically, the section studied consisted of monotonous dark olive-coloured shelly silts and silty sands, with small pebbles and clay clasts at some levels near the base. Pyrite and plant debris form minor constituents.

Klinger & Kennedy (1977) have described the ammonites from the BH–9 borehole and recognized three well-defined ammonite assemblages, which they were able to compare with those from Umzamba, elsewhere in Zululand, and Madagascar. On the basis of these faunal comparisons the lower part of the borehole (159–114 m) is allocated a middle and upper Santonian age, whilst the upper part (114–65 m) belongs to the lower Campanian. Local assemblages allow a subdivision of the Campanian sequence into two faunas (Campanian I and II) with the boundary placed at about 90 m. The succession appears to be complete.

Thirty-three cored samples were available for microfossil analyses between 82,03 m and 150 m, and these gave good coverage from the base of the borehole to the lower part of the Campanian II (Fig. 32, Table 1). Each sample consisted of half a core, about 25 mm radius and about 40 mm in length. Ostracods were extracted by the normal washing techniques and are illustrated herein by SEM photographs taken on a Cambridge Instruments Stereoscan 180 of the Electron Microscopy Unit at the University of Cape Town. Specimens were mounted on double-sided sellotape and were gold/palladium coated.

SYSTEMATIC DESCRIPTIONS

The classification used here is based mostly on the Ostracod Treatise (Moore 1961), with various additions necessitated by recent work. Morphological terms have been supplemented by those introduced to cover features visible at high magnifications (e.g. Sylvester-Bradley & Benson 1971).

TABLE 1
Vertical distribution of ostracod species in the BH9 borehole.
Figures on the left are depths of samples beneath surface in metres. The stratigraphy is based on the ammonite studies of Klinger & Kennedy (1977).

Ostracods

	Borehole depth	*Cythereis transkeiensis*	*Cytherelloidea newtoni*	*Brachycythere longicaudata*	*Paracypris umzambaensis*	*Paracypris zululandensis*	*Haughtonileberis haughtoni*	*Cytherella* sp. 2	*Cytherella* sp. 4	*Rayneria nealei*	*Brachycythere sicarius*	*Brachycythere pondolandensis*	*Gibberleberis africanus*	*Cythereis klingeri*	*Bairdoppilata andersoni*	*Cytherella* sp. 3	*Bythocypris richardsbayensis*	*Cytherelloidea umzambaensis*	*Haughtonileberis fissilis*	*Cytherella* sp. 1	*Pondoina sulcata*	*Amphicytherura tumida*	*Oertliella pennata*	*Gibberleberis elongata*	*Oertliella* sp. A	*Cytherelloidea griesbachi*	*Haughtonileberis vanhoepeni*	*Trachyleberis zululandensis*	*Trachyleberis minima*	*Amphicytherura zululandensis*	*Cytherelloidea contorta*	*Oertliella africana*	*Xestoleberis* sp. A	*Hermanites kennedyi*	*Unicapella sacsi*	*Unicapella reticulata*
	82,0				*			*	*		*			*	*	*	*	*		*								*				*	*	*		
	87,0			*		*		*						*	*	*	*		*	*						*						*	*	*	*	
II	88,0			*	*	*		*	*		*			*	*	*	*	*	*	*			*	*	*	*						*	*	*	*	*
	89,0				*			*	*		*				*								*											*		
I	92,3			*	*		*	*						*	*		*									*	*						*			
	97,5			*	*		*				*			*	*	*	*	*	*				*							*						
	100,0			*	*	*		*	*		*			*	*		*	*	*				*				*			*			*			
	102,2			*		*	*	*	*		*			*	*	*	*			*			*				*					*				
	106,0			*		*	*	*	*	*	*			*	*	*	*	*					*		*	*	*			*		*				
CAMPANIAN	110,0			*	*	*		*			*			*	*		*		*	*		*						*	*	*	*					
	115,2			*	*		*			*					*				*			*														
SANTONIAN	115,9			*	*			*	*	*				*	*			*	*				*		*	*	*									
	118,2				*		*			*	*		*	*		*							*													
	119,8		*	*	*		*		*				*	*																						
	120,2		*	*	*		*		*				*	*				*					*													
	123,0			*	*									*									*													
	123,5			*		*	*			*			*	*			*			*																
	124,0			*	*		*			*	*	*		*										*												
	125,0			*	*		*							*								*														
	125,5			*			*				*			*																						
	127,8						*				*			*				*																		
	128,0		*	*	*		*	*		*	*	*	*	*			*				*	*		*												
	131,5			*			*												*																	
	135,4			*	*	*	*																													
	139,8			*	*		*		*	*				*	*		*	*			*	*	*													
	142,0			*	*		*			*	*			*			*		*			*														
	143,0			*	*		*		*		*			*			*				*															
	145,0			*		*	*			*			*						*																	
	151,1		*	*	*		*			*	*	*		*				*																		
	152,0			*	*		*		*		*		*	*	*		*		*	*																
	157,0		*	*	*		*	*	*	*	*	*	*	*	*	*	*	*																		

Abbreviations

RV	right valve
LV	left valve
MPC	marginal pore canals
SCT	subcentral tubercle
ATE	anterior terminal element
PTE	posterior terminal element
ME	median element
AM	anterior margin
PM	posterior margin
DM	dorsal margin
VM	ventral margin
NPC	normal pore canals
MA	marginal areas

Subclass OSTRACODA Latreille, 1806

Order PODOCOPIDA Müller, 1894

Suborder PLATYCOPINA Sars, 1866

Family **Cytherellidae** Sars, 1866

Members of this family constitute one of the main elements of the ostracod fauna (Fig. 32). They are important in the lowermost few metres of the borehole (up to 21%) where the genus *Cytherelloidea* is well represented, and in the upper half (up to 28%) where *Cytherella* occurs abundantly. Between 152 m and 123 m (assemblages 2–3) the family forms only a minor component (<10%) of the population.

Not only does the family occur in relatively large numbers, but it is also diverse (5 species and 4 morphotypes recognized).

Genus *Cytherella* Jones, 1849

Four morphotypes have been distinguished in BH–9. These probably represent separate species, but will not be designated until further samples from the Santonian/Campanian of Zululand have been studied. All four are found throughout the borehole, but none is common below the Santonian/Campanian boundary.

Cytherella Sp. 1

Fig. 2A–C

RV and LV differ considerably in shape. In LV the VM and DM are straight and the PM asymmetrically curved, with a pronounced dorsal slope. In the RV the DM is 'pitched', but not arched. In both valves the posterior ends carry puntae with stellate outlines.

Range

Santonian to Campanian II, but only common in Campanian II.

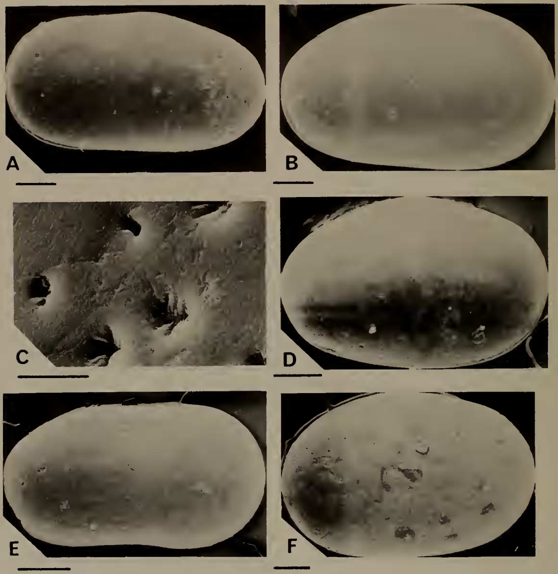

Fig. 2. *Cytherella.* A. *Cytherella* sp. 1, SAM–K5567, BH9 82,03 m, LV. B. *Cytherella* sp. 1, SAM–K5568, BH9 82,03 m, RV. C. *Cytherella* sp. 1, SAM–K5568, BH9 82,03 m, detail of ornamentation posterior part of LV. D. *Cytherella* sp. 2, SAM–K5569, BH9 82,03 m, R.V E. *Cytherella* sp. 3, SAM–K5570, BH9 82,03 m, RV. F. *Cytherella* sp. 4, SAM–K5571, BH9 82,03 m, RV.

Scale bars: C = 10μ, others = 100μ.

Cytherella Sp. 2

Fig. 2D

This form has an oval outline and a compressed anterior region when seen in dorsal view. The DM is arched and the VM gently convex.

Range

Santonian to Campanian II, but only common in Campanian I–II.

Cytherella Sp. 3

Fig. 2E

An elongate form with a waisted lateral outline. AM symmetrically rounded, PM asymmetrically curved.

Range

Santonian to Campanian II, but only common in Campanian I–II.

Cytherella Sp. 4

Fig. 2F

This morphotype resembles *C.* Sp. 2, but differs in having a moderately inflated posterior area and a slightly less arched DM.

Range

Santonian to Campanian II.

Genus *Cytherelloidea* Alexander, 1929

Cytherelloidea umzambaensis Dingle, 1969

Figs 3A, 4A–B

?Cytherella williamsoniana Jones 1849, Chapman, 1904: 236.
Cytherelloidea umzambaensis Dingle, 1969: 351–353, fig. 3.

This species occurs in small numbers (maximum 9 %) throughout the borehole, but is slightly more abundant and consistently present in the Campanian part. It is clearly an environmentally-tolerant species, with a preference for moderate water depths (assemblage 4). In its type section (the Santonian of Umzamba) it is moderately abundant (5–12 %).

Range

Santonian to Campanian II.

Cytherelloidea cf. *C. gardeni* Dingle, 1971

Cytherelloidea delicata sp. nov. Dingle, 1969: 353–354, fig. 4.
Cytherelloidea gardeni nom. nov. Dingle, 1971*a*: 353.

One specimen, possibly referable to this delicately reticulate species, was found in the Santonian part of the borehole (sample at 139,8 m).

Range

Santonian.

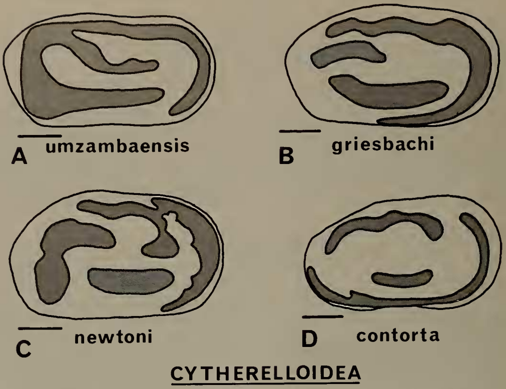

Fig. 3. Sketches of *Cytherelloidea* species right values with positive features shaded. A. *C. umzambaensis* Dingle, 1969, BH9 120,22 m. B. *C. griesbachi* sp. nov., holotype, SAM–K5575, BH9 88,39 m. C. *C. newtoni* sp. nov., holotype, SAM–K5574, BH9 120,22 m. D. *C. contorta* sp. nov., holotype SAM–K5576, BH9 110,0 m.

Scale bars all 100μ.

Cytherelloidea newtoni sp. nov.

Figs 3C, 4C

Derivation of name

In honour of Dr R. Bullen-Newton for his contributions to the geological knowledge of Zululand.

Holotype

SAM–K5574, RV, BH–9, 120,22 m, Richards Bay, Santonian.

Dimensions

Length 0,46 mm, height 0,28 mm.

Diagnosis

Species with a right-angle-shaped ridge in the posteroventral part of the valve.

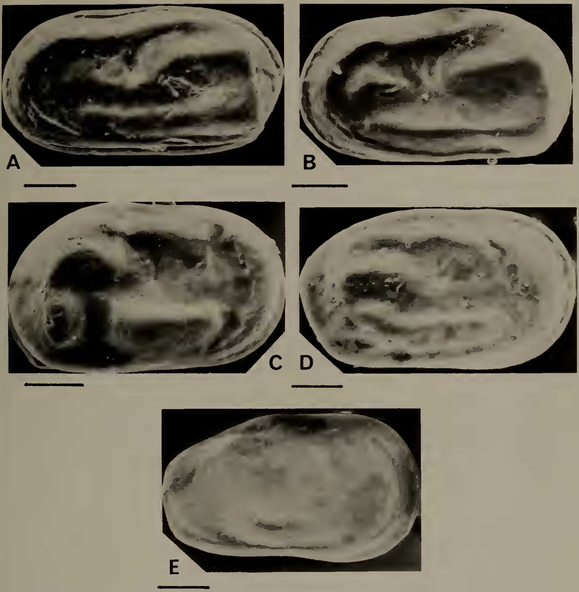

Fig. 4. *Cytherelloidea.* A. *C. umzambaensis* Dingle, 1969, SAM–K5572, Umzamba cliff, LV. B. *C. umzambaensis* Dingle, 1969, SAM–K5573, BH9 106,0 m, LV. C. *C. newtoni* sp. nov., holotype, SAM–K5574, BH9 120,22 m, RV. D. *C. griesbachi* sp. nov., holotype, SAM–K5575, BH9 88,39 m, RV. E. *C. contorta* sp. nov., holotype, SAM–K5576, BH9 110,0 m, RV. Scale bars all 100μ.

Description

External features. In lateral view AM symmetrically rounded, PM asymmetrically rounded with a gently sloping posterodorsal part. Greatest height lies over the posterodorsal angle, giving the valve a hump-backed outline. VM nearly straight. Surface bears several short, rounded ridges; an anterior ridge with a scalloped posterior edge, a short, high ventrolateral ridge, a right-angle-shaped ridge in a posteroventral/posteromedian location, and a sinuous dorsolateral ridge which terminates anteriorly in a median expansion. All these ridges are separated, giving the surface a rather knobbly appearance.

No internal features seen.

Remarks

The humped dorsal margin and distinctive rib disposition give this species easily recognizable characters. It is restricted to the lower (Santonian) part of the borehole, suggesting that it was environmentally bound to shallow-water environments. *C. newtoni* has not been found at Umzamba.

Range

Santonian.

Cytherelloidea griesbachi sp. nov.

Figs 3B, 4D

Derivation of name

In honour of Dr C. L. Griesbach for his contribution to the geological knowledge of the Cretaceous rocks of south-east Africa.

Holotype

SAM–K5575, RV, BH–9, 88,39 m, Richards Bay, Campanian II.

Dimensions

Length 0,51 mm, height 0,30 mm.

Diagnosis

Species with three longitudinal ridges, the ventromedian one being upturned posteriorly.

Description

External features. In lateral view, AM symmetrically rounded, PM asymmetrically and bluntly pointed, being ventrally truncated and gently sloping dorsally. Highest part of the valve at about mid-length. Surface bears three longitudinal ridges. The dorsal ridge is slightly sinuous, and joins a wide, raised anterior area which does not really deserve the description of a ridge. The median ridge is short and confined to the posterior third, whilst the ventral ridge is upturned posteriorly, and is separate from the anterior raised area. The posterior part of the valve is compressed, and there is a conspicuous, flat posteroventral area. Several small pustules occur in the posterodorsal part of the valve surface. No internal features seen.

Remarks

The rib disposition of *C. griesbachi* is similar to that of *C. umzambaensis*, but the two differ significantly in general outline (*C. umzambaensis* is more elongate) in the shape of the ridges in the posteroventral area, and in their posterodorsal outlines (Fig. 3). *C. griesbachi* is rare in the borehole and first appears just below the base of the Campanian. One specimen, possibly referable to this species, has been found at Umzamba.

Range

Uppermost Santonian to Campanian II.

Cytherelloidea contorta sp. nov.

Figs 3D, 4E

Derivation of name

Reference to its rather unusual shape and rib disposition.

Holotype

SAM–K5576, RV, BH–9, 110 m, Richards Bay, Campanian I.

Dimensions

Length 0,50 mm, height 0,28 mm

Diagnosis

Species with a strongly asymmetric and narrow posterolateral outline, a marginal rim, and subdued ventrolateral and dorsolateral ridges. There is no ridge.

Description

External features. In lateral view, rounded AM, but a curiously 'contorted' posterior outline. The dorsal part slopes gently down, whilst the ventral part is truncated. Highest part of the valve lies in the anterior third. Ventral outline concave, DM short and straight. Surface smooth, and ornamented with short, subdued ridges. There is a narrow marginal rim that extends from the anterior cardinal angle, to the midpoint of the PM. A short, rounded and rather indistinct ventrolateral ridge, highest at its posterior end, lies at about midlength, and there is a sinuous dorsal ridge which has swellings at its posterior and anterior ends. There is no median ridge.

Internal features not seen.

Remarks

This unusually shaped species occurs in only one sample (110 m, Campanian I), but is very distinctive in its shape and rib disposition by which it is easily distinguished from the other species in the borehole. No representatives of *C. contorta* have been recorded from Umzamba. Its closest relative is *C. westaustraliensis* Bate, 1972, from the Santonian and Campanian of western Australia. The two species have similar ornamentation, but differ in their posterodorsal outlines and size (the Australian species is more evenly rounded posteriorly, and much larger, typically about 0,90 mm in length).

Range

Campanian I.

Suborder PODOCOPINA Sars, 1866

Superfamily BAIRDIACEA Sars, 1888

Family **Bairdiidae** Sars, 1888

Genus *Bairdoppilata* Coryell, Sample & Jennings, 1935

Bairdoppilata andersoni sp. nov.

Fig 5A–F

Derivation of name

In honour of Dr W. Anderson for his contribution to Zululand stratigraphy.

Holotype

SAM–K5577, RV, BH–9, 88,39 m, Richards Bay, Campanian II

Paratypes

SAM–K5578, LV, BH–9, 88,39 m, Richards Bay, Campanian II
SAM–K5579, RV, BH–9, 88,76 m, Richards Bay, Campanian II
SAM–K5580, LV, BH–9, 88,76 m, Richards Bay, Campanian II
SAM–K5581, Carapace, BH–9, 88,39 m, Richards Bay, Campanian II

Dimensions

	length mm	height mm	width mm
K–5577	1,45	0,80	
K–5578	1,50	0,90	
K–5579	1,48	0,80	
K–5580	1,49	0,95	
K–5581	1,10		0,59

Diagnosis

Species in which LV and RV differ in shape especially in the lateral outlines of the AM, PM and DM.

Description

External features. In lateral view, LV and RV differ in shape. The RV has the classical 'Bairdia' outline with upturned posterior and anterior outlines. The VM is slightly concave about midlength. The LV has a more 'almond' shape with no noticeable upturn of the PM and a more rounded DM. In dorsal view

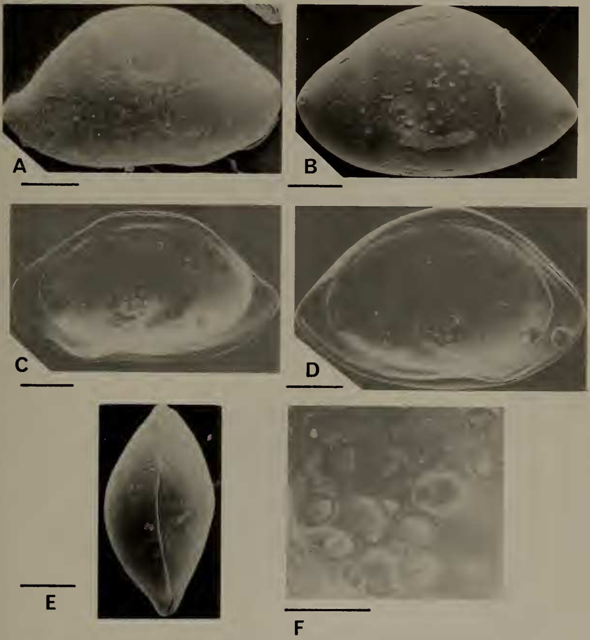

Fig. 5. *Bairdoppilata andersoni* sp. nov. A. Holotype, SAM–K5577, BH9 88,39 m, RV. B. SAM–K5578, BH9 88,39 m, LV. C. SAM–K5579, BH9 88,76 m, internal RV. D. SAM–K5580, BH9 88,76 m, internal LV. E. SAM–K5581, BH9 88,39 m, dorsal view, carapace. F. SAM–K5580, BH9 88,76 m, muscle scars, LV.

Scale bars: F = 100μ, others = 300μ.

the LV is more inflated. The valve surface is finely pitted all over, and possesses numerous large normal pore canal openings.

Internal features. Hinge typical for the genus, with very fine serration on the bars at the anterior and posterior ends of the RV flange groove. MS in LV consist of an anteriorly opening semi-circlet of 8 spots enclosing two large and two small spots, with a further two small spots anterodorsally. All spots are rounded. MA moderately wide with small anterior vestibules.

Remarks

Bairdoppilata andersoni shows considerable intra-specific variation in lateral outline and with further study it may be possible to effect further subdivision. Its distribution in the Richards Bay borehole is remarkably clear cut—throughout the Santonian section four specimens were recovered (assemblages 1–2), whilst in the Campanian rocks it is the dominant ostracod—up to 40% of the total fauna. Its appearance in large numbers is sudden and coincides with the Santonian/Campanian boundary where it marks the establishment of open ocean low energy conditions (assemblage 4). Towards the top of the section, as the water deepens further, its total numbers continue to increase although with the influx of a large population of Platycopina it still maintains about a 40 per cent level of the total population.

Bairdoppilata sp. (probably *andersoni*) has been recorded from Umzamba as rare, single valves.

Range

Santonian to Campanian II.

Genus *Bythocypris* Brady, 1880

Bythocypris richardsbayensis sp. nov.

Fig. 6A–E

Derivation of name

Locality of type.

Holotype

SAM–K5582, LV, BH–9, 88,39 m, Richards Bay, Campanian II.

Paratypes

SAM–K5583, RV, BH–9, 106,00 m, Richards Bay, Campanian I
SAM–K5584, Carapace, BH–9, 88,5 m, Richards Bay, Campanian II

Dimensions

		length mm	height mm
K5582		0,55	0,28
K5583		0,48	0,26
K5584	RV	0,47	0,24
K5584	LV	0,48	0,28

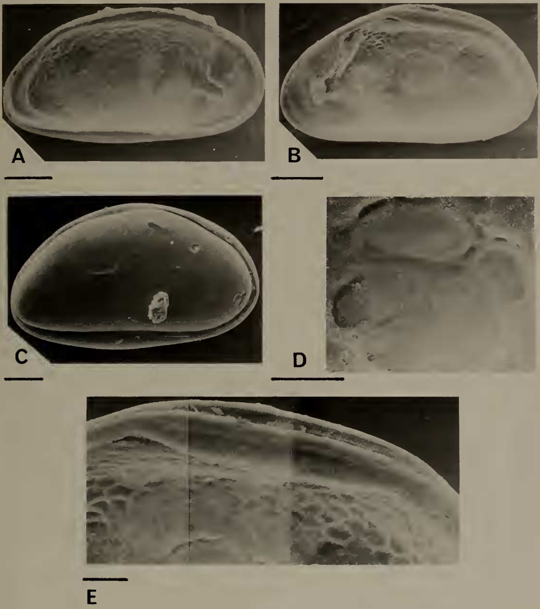

Fig. 6. *Bythocypris richardsbayensis* sp. nov. A. Holotype, SAM–K5582, BH9 88,39 m, internal LV. B. SAM–K5583, BH9 106,0 m, internal RV. C. SAM–K5584, BH9 88,5 m, carapace, RV. D. SAM–K5583, BH9 106,0 m, muscle scars, RV. E. SAM–K5583, BH9 106,0 m, hinge, RV.

Scale bars: D–E = 30μ, others = 100μ.

Diagnosis

An elliptical species with reticulate ornamentation on the inside surface of the outer lamella.

Description

External features. In lateral view, LV larger than RV, overlaps around entire margin, but especially along VM. RV : AM asymmetrically rounded, truncated dorsally, PM rounded, greatest height just in front of midlength. LV : AM symmetrically rounded, and PM asymmetrically rounded, truncated dorsally, greatest height at midlength. Surface smooth.

Internal features. Hinge: a smooth bar in RV fits into a shallow groove in the LV. The bar is downward projecting in lateral view, and is thickest at its anterior end. MS consist of rosette of four petal-like ventral scars and an E–W-elongated dorsal scar. MA: anterior is wide with a prominent, anteriorly tapering vestibule; posterior is narrow. MPC: 12 fine, straight canals radiate from the apex of the anterior vestibule; 6 very short fine posterior canals. The inside surface of valve is ornamented with reticulation of polygonal fossae (mostly hexagonal) and narrow muri.

Remarks

In shape and hinge, *B. richardsbayensis* is very similar to *B. howchiniana* Chapman, 1917, as illustrated by Neale (1975) from the Santonian of Australia. The MS of the latter are reported to consist of a cluster of 4 large scars, whereas the illustration (plate 5 fig. 2b of Neale 1975) suggests that 5 are present—in which case the similarity with *B. richardsbayensis* would be even closer. The main outstanding difference is the presence of reticulation in the inner surface of the outer lamella in the South African species.

B. richardsbayensis occurs sporadically throughout the Richards Bay borehole but it is most abundant (12 %) and consistent in the Campanian (I–II) and lower Santonian parts, and is absent from the uppermost Santonian rocks (assemblage 3).

Range

Santonian to Campanian II.

Superfamily CYPRIDACEA Baird, 1845

Family **Paracyprididae** Sars, 1923

Genus *Paracypris* Sars, 1866

Of the non-Cytheracean types, this genus is the most consistently present throughout the borehole. It never occurs in large numbers, however (maximum of about 11 %), and is most abundant in the Santonian section (i.e. prefers the shallower water, higher energy environments of assemblages 1–3).

Paracypris umzambaensis Dingle, 1969

Figs 7A–C, 9A

Macrocypris simplex Chapman 1898, Chapman, 1904: 233, pl. 29 (fig. 22).
Paracypris? umzambaensis Dingle, 1969: 354–356, fig. 5.

This species was provisionally placed in *Paracypris* by Dingle (1969) because the MS had not been seen at that time. SEM pictures obtained during the present study confirm the original assignment. Two varieties of the species occur—a slender variety with a markedly pointed PM, and a fatter variety with a less acuminate posterior outline. Both varieties occur in the Richards Bay borehole and at Umzamba. The species occurs throughout the borehole section but is most abundant in the Santonian (up to 11 %) and rare (up to 3 %) in the Campanian. The fatter variety is similar in outline to *Paracypris* sp. nov. described by Neale (1975) from the Santonian of western Australia.

Range

Santonian to Campanian II.

Paracypris zululandensis sp. nov.

Figs 7D–G, 9B

Derivation of name

Location of borehole.

Holotype

SAM–K5588, RV, BH–9, 106,00 m, Richards Bay, Campanian I

Paratypes

SAM–K5589, LV, BH–9, 110,00 m, Richards Bay, Campanian I
SAM–K5590, LV, BH–9, 110,00 m, Richards Bay, Campanian I
SAM–K5591, RV, BH–9, 110,00 m, Richards Bay, Campanian I

Dimensions

	length mm	height mm
K5588	0,73	0,37
K5589	0,75	0,38
K5590	0,78	0,42
K5591	0,73	0,35

Diagnosis

A plump species with a tapering, rounded posterior outline.

Description

External features. In lateral view AM is rounded, slightly extended in the RV, PM tapers but is distinctly round and curves upwards at the posteroventral corner. DM strongly arched and VM convex in LV and slightly concave in RV. Surface smooth.

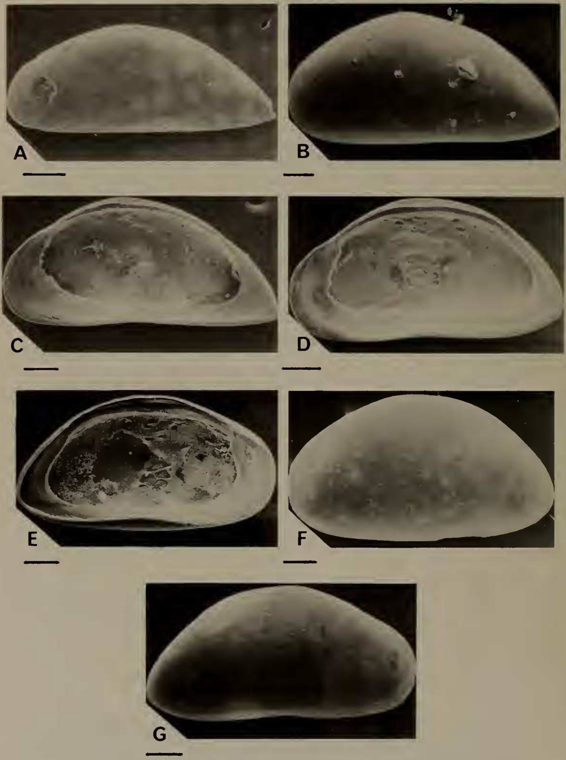

Fig. 7. *Paracypris*. A. *P. umzambaensis* Dingle, 1969, SAM–K5585, Umzamba cliff, slim variety, LV. B. *P. umzambaensis* Dingle, 1969, SAM–K5586, BH9 88,39 m, plump variety, LV. C. *P. umzambaensis* Dingle, 1969, SAM–K5587, BH9 118,22 m, plump variety, RV. D. *P. zululandensis* sp. nov., holotype, SAM–K5588, BH9 106,0 m, internal RV. E. *P. zululandensis*, sp. nov., SAM–K5589, BH9 110,0 m, internal LV. F. *P. zululandensis*, sp. nov., SAM–K5590, BH9 110,0 m, LV. G. *P. zululandensis* sp. nov., SAM–K5591, BH9 110,0 m, RV. Scale bars all 100μ.

Internal features. Hinge consists of a thick bar (RV) and a corresponding groove and dorsal lip (LV). MS: cluster of five scars and a large, elliptical dorsal scar, MA wide, with a wide anterior vestibule that extends almost to the anterior margin. Seven anterior and five posterior thin, indistinct MPC.

Remarks

P. zululandensis is difficult to distinguish from the plumper varieties of *P. umzambaensis*. The two differ on: degree of acumination of PM, ventral outline (straighter in *umzambaensis*), more acutely arched DM of *umzambaensis*, and details of MS pattern (Fig. 9).

P. zululandensis occurs in small numbers (up to 5%) sporadically throughout the Richards Bay borehole. It is most consistently present just above the Santonian/Campanian boundary (assemblage 4).

Range

Santonian to Campanian II.

Superfamily CYTHERACEA Baird, 1850

Except in the uppermost part of the borehole (above 88 m, assemblage 5) Cytheracea are numerically the largest part of the ostracod population. They are the dominant component in the Santonian section (up to 90% of the fauna), but steadily decrease in importance upwards (between 50% and 38% in the Campanian section).

Family **Xestoleberididae** Sars, 1928

Xestoleberis sp. A

Fig. 8

This species occurs in minor amounts (up to 7%) in the upper part of the borehole (i.e. Campanian II and the upper part of Campanian I). It has a

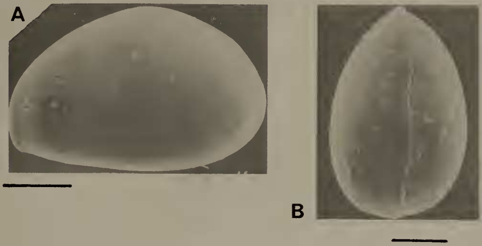

Fig. 8. *Xestoleberis* sp. A. A. SAM–K5592, BH9 88,5 m, LV. B. SAM–K5593, BH9 88,5 m, dorsal view, carapace.

slightly convex ventral outline in lateral view and a weakly developed antero-ventral marginal rim. In dorsal view the LV overlaps the RV prominently at the anterior end, and the carapace is inflated medianly. Until the borehole specimens can be compared with other material from Zululand (the genus is well represented in Campanian and Maastrichtian samples) it is not advisable to attempt to formally designate the new species.

Illustrated specimens

SAM–K5592, LV, BH–9, 88,50 m, Richards Bay, Campanian II
SAM–K5593, Carapace, BH–9, 88,50 m, Richards Bay, Campanian II

Dimensions

	length mm	height mm	width mm
K5592	0,37	0,23	
K5593	0,38		0,24

Range

Campanian I–II.

Family **Cytherideidae** Sars, 1925

Genus *Pondoina* Dingle, 1969

Pondoina sulcata Dingle, 1969

Fig. 9C

Pondoina sulcata Dingle, 1969: 356–358, fig. 6.

This species occurs as a rare component in the middle part of the Santonian section of BH–9, where the specimens are poorly preserved. In contrast it occurs moderately abundantly (10–15%) throughout the Santonian sequence at Umzamba. A sketch of MS is included here to supplement the original descriptions.

Range

Santonian.

Family **Schizocytheridae** Mandelstam, 1960

Genus *Amphicytherura* Butler & Jones, 1957

Amphicytherura tumida Dingle, 1969

Fig. 10A–F

Amphicytherura (*A.*) *tumida* Dingle, 1969: 368–370, fig. 13.

This species was first recorded in the Santonian rocks at Umzamba, where it forms a minor element of the fauna (2–10%). In the Richards Bay borehole it occurs in small numbers (up to 10%) and its range extends from the lower part of the sequence into Campanian I. It is, however, absent from the uppermost

Fig. 9. Muscle scars. A. *Paracypris umzambaensis* Dingle, 1969, Umzamba cliff, LV. B. *Paracypris zululandensis* sp. nov., SAM–K5589, BH9 110,0 m, LV. C. *Pondoina sulcata* Dingle, 1969, Umzamba cliff, LV.
Scale bars all 30μ.

Santonian, and across the Santonian/Campanian boundary. Some of the specimens in BH–9 are very well preserved and are illustrated to supplement the original descriptions given by Dingle (1969).

Range

Santonian to Campanian I.

Amphicytherura zululandensis sp. nov.

Fig. 11A–G

Derivation of name

Locality of borehole.

Holotype

SAM–K5598, RV, BH–9, 97,5 m, Richards Bay, Campanian I

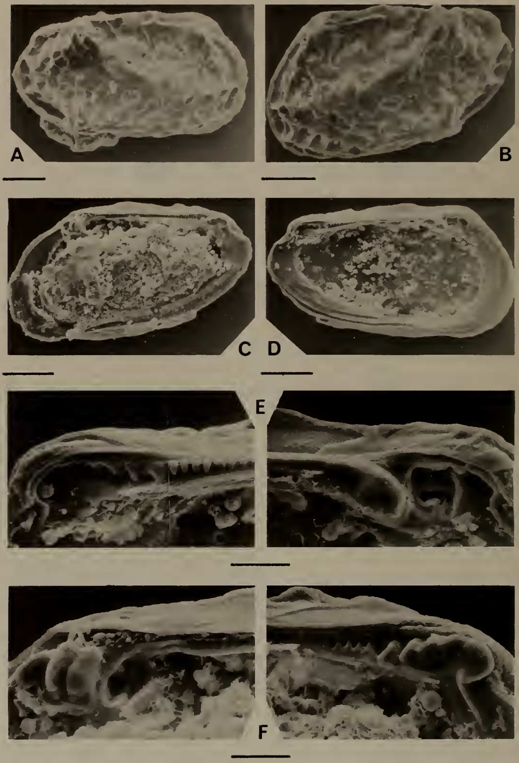

Fig. 10. *Amphicytherura tumida* Dingle, 1969. A. SAM–K5594, BH9 125,0 m, RV. B. SAM–K5595, BH9 139,8 m, LV. C. SAM–K5596, BH9 128,0 m, internal RV. D. SAM–K5597, BH9 128,0 m, internal LV. E. SAM–K5597, BH9 128,0 m, hinge LV. F. SAM–K5596, BH9 128,0 m, hinge RV.

Scale bars: E–F = 30μ, others = 100μ.

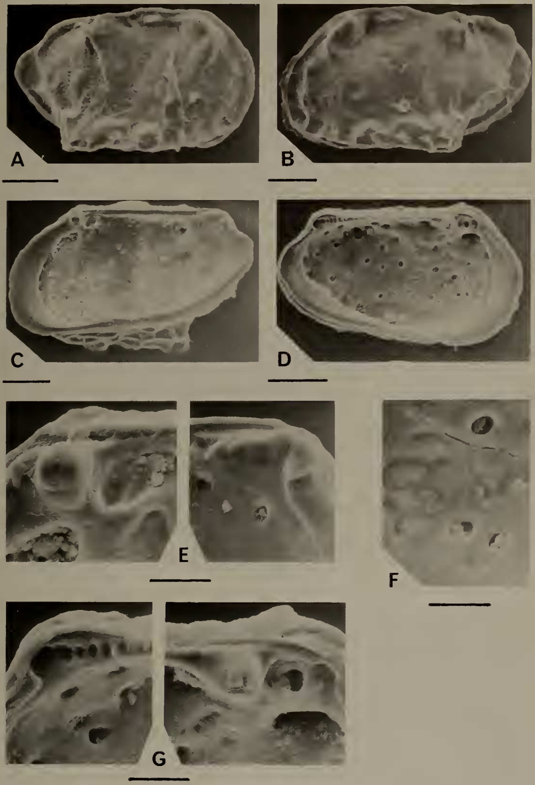

Fig. 11. *Amphicytherura zululandensis* sp. nov. A. Holotype, SAM–K5598, BH9 97,5 m, RV. B. SAM–K5599, BH9 97,5 m, LV. C. SAM–K5600, BH9 110,0 m, internal RV. D. SAM–K5601, BH9 110,0 m, internal LV. E. SAM–K5600, BH9 110,0 m, hinge RV. F. SAM–K5601, BH9 110,0 m, muscle scars, LV. G. SAM–K5601, BH9 110,0 m, hinge LV.

Scale bars: E–G = 30μ, others = 100μ.

Paratypes

SAM–K5599, LV, BH–9, 97,5 m, Richards Bay, Campanian I
SAM–K5600, RV, BH–9, 110,00 m, Richards Bay, Campanian I
SAM–K5601, LV, BH–9, 110,0 m, Richards Bay, Campanian I

Dimensions

	length mm	height mm
K5598	0,53	0,30
K5599	0,42	0,26
K5600	0,42	0,23
K5601	0,55	0,30

Diagnosis

Species with prominent posteroventral alae, the under surfaces of which are coarsely reticulate.

Description

External features. Quadrate in lateral view. AM symmetrically rounded, PM bluntly pointed. DM nearly straight, VM strongly upturned posteriorly, but outline is obscured by a small ala which has a pointed, right-angled posterior corner. The undersides of the alae are coarsely reticulate. Lateral valve surface is uneven, with three main irregular, raised areas and a north–south median depression. A prominent eye spot lies on a short, curved ridge, and there is a prominent hump below the posterior cardinal angle. Overall, the surface is smooth, finely punctate (especially in the posterior half), locally faintly reticulate and bears a few, scattered pustules.

Internal features. Hinge strongly schizodont with the PTE of the RV undercut posteriorly. MS consist of a curved posterior row of four rounded scars, and two rounded frontal scars. Internal openings of the NPC are prominent. MA wide with 7–9 anterior and 5 posterior MPC.

Remarks

A. zululandensis is closely allied to *A. tumida*, but differs in lacking a median lateral ridge, a SCT, and in having more prominent posteroventral alae. There are also subtle differences in the hinge structure (e.g. the anterior part of the ME in LV is elongate and sloping in *A. tumida*, whilst it is shorter and not inclined in *A. zululandensis*).

A. zululandensis occurs in small numbers in the Campanian I section of the borehole, where its range overlaps with that of *A. tumida* over a short section (4–5 m).

Range

Campanian I.

Family **Brachycytheridae** Puri, 1954

Genus *Brachycythere* Alexander, 1933

Numerically this is the most important genus in the borehole. In the lower (Santonian) half, it commonly forms more than 30 per cent of the total ostracod population, and near the base reaches 56 per cent at one horizon (Fig. 32). A rapid decline takes place in the upper part of the Santonian (between 120 and 124 m), above which it reaches >20 per cent at one horizon only (at the Campanian I–II boundary). A similar distribution was recorded from the Santonian rocks at Umzamba where the genus made up >30 per cent of the population in all four samples studied by Dingle (1969).

Brachycythere longicaudata (Chapman, 1904)

Figs 12A–C, 13A–D

Cytheridea longicaudata Chapman, 1904: 234, pl. 29 (fig. 21). Howe & Laurencich, 1958: 279.
Cythere ?drupacea Jones 1884, Chapman, 1904: 234.
Brachycythere longicaudata (Chapman), Dingle, 1969: 358–361, fig. 7.

Dingle (1969) erected a neotype on topotypic material from the Santonian section at Umzamba, where *B. longicaudata* is the dominant element in the fauna (about 30%). It is found in two morphotypes, elongate and squat, in addition to which there is considerable small-scale variation within the population; ornamentation, shape of the ventrolateral overhang, outline of the AM and PM, and even in the MS pattern.

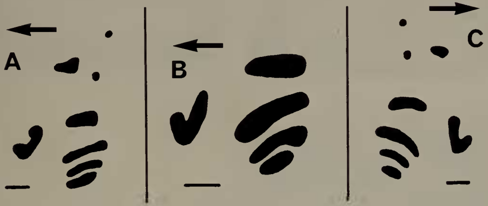

Fig. 12. Muscle scars of *Brachycythere longicaudata* (Chapman, 1904). A. SAM–K5605, BH9 88,39 m, RV. B. Umzamba cliff, RV. C. Umzamba cliff, LV. Scale bars all 30μ.

B. longicaudata occurs throughout BH–9 (mid Santonian to Campanian II), and, as at Umzamba, it is the dominant element in the lower half of the Santonian section (up to 50%) and an important element in the rest of the succession (up 12% in Campanian II and 22% in the Upper Santonian). This large, robust species was obviously tolerant of varying environmental conditions, as indicated by its re-establishment after the faunal break that marks the local Santonian/Campanian boundary.

Range

Santonian to Campanian II.

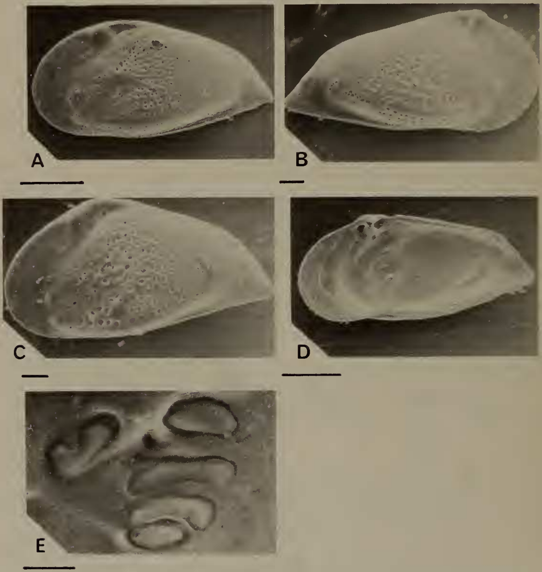

Fig. 13. *Brachycythere.* A. *B. longicaudata* (Chapman, 1904), SAM–K5602, BH9 88,39 m, LV. B. *B. longicaudata* (Chapman, 1904), SAM–K5603, BH9 106,2 m, RV. C. *B. longicaudata* (Chapman, 1904), SAM–K5604, BH9 92,27 m, LV. D. *B. longicaudata* (Chapman, 1904), SAM–K5605, BH9 88,39 m, internal RV. E. *B. sicarius* sp. nov., SAM–K5608, BH9 97,5 m, muscle scars, RV.

Scale bars: E = 30μ, B–C = 100μ, A, D = 300μ.

Brachycythere pondolandensis Dingle, 1969

Brachycythere pondolandensis Dingle, 1969: 361–362, fig. 8.

This small, rounded, and relatively ornate species is rare in the Richards Bay borehole, where it reaches a maximum of about 8 per cent at the top of its range. It is confined to rocks of Santonian age. It is also rare in the Santonian of Umzamba, its type locality, and may prove to be a good marker fossil for Santonian rocks in south-east Africa. Its preservation is never good, suggesting that it may have readily been destroyed in sections that are not completely fresh.

Range

Santonian.

Brachycythere sicarius sp. nov.

Figs 13F, 14A–F

Derivation of name

From the Latin *sica* (a dagger or dirk), reference to dagger-like alae spines.

Holotype

SAM–K5606, RV, BH–9, 89,0 m, Richards Bay, Campanian II

Paratypes

SAM–K5607, LV, BH–9, 88,39 m, Richards Bay, Campanian II
SAM–K5608, RV, BH–9, 97,5 m, Richards Bay, Campanian I
SAM–K5609, LV, BH–9, 97,5 m, Richards Bay, Campanian I

Dimensions

	length mm	height mm
K5606	0,85	0,40
K5607	0,82	0,42
K5608	0,79	0,40
K5609	0,80	0,42

Diagnosis

Species with pronounced, ventrolateral, keeled alae, coarse circular fossae on the median lateral surface, and coarse anterior and posterior marginal spines.

Description

External features. Triangular in lateral view. Rounded AM and pointed PM. DM and VM straight, converging posteriorly, but ventral outline is convex because of ventrolateral overhang by an ala with a keel-like outer edge. The AM carries several coarse, stubby spines, whilst the posteroventral area typically carries two or three posteriorly pointing dagger-like spines. A further large spine occurs at the posterior end of the ala, although this is retained only on well-preserved specimens. The lateral surface is covered all over with rounded fossae which are largest along the inner edge of the alae. There is a prominent anterior

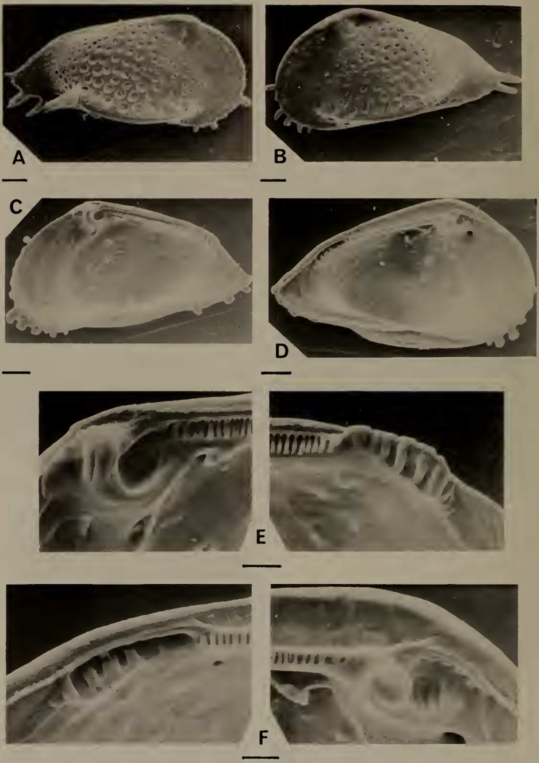

Fig. 14. *Brachycythere sicarius* sp. nov. A. Holotype, SAM–K5606, BH9 89,0 m, RV. B. SAM–K5607, BH9 88,39 m, LV. C. SAM–K5608, BH9 97,5 m, internal RV. D. SAM–K5609, BH9 97,5 m, internal LV. E. SAM–K5608, BH9 97,5 m, hinge RV. F. SAM–K5609, BH9 97,5 m, hinge LV.

Scale bars: E–F = 30μ, others = 100μ.

cardinal angle, on which is situated a rounded, subdued eye spot, with a distinct post-ocular sulcus (especially in the LV).

Internal features. Hemiamphidont hinge. In RV, ATE is a dentate peg, with a denticulate dorsal surface, and PTE is an elongate dentate bar with six teeth. The ME consists of a crenulate bar with an anterior, inclined rectangular peg. MS consist of four elongate posterior scars and a hooked anterior scar. MA wide with 20–23 long, slender, irregular anterior and 12 posterior MPC. The latter are concentrated on the ventral side.

Remarks

Although typical, well-preserved specimens of *B. sicarius* are easily separated from examples of *B. longicaudata* by their spinose, alate outline and punctate ornamentation, poorly-preserved specimens may be confused with the more angular varieties of the latter species. A somewhat similar species, *B. angulata* Grekoff has been recorded from the Coniacian–Campanian of West Africa (e.g. Apostolescu 1961). It possesses short keeled alae, but lacks the coarse reticulation and spines of *B. sicarius.*

B. sicarius occurs in small numbers (maximum of 11 %) throughout BH–9, but is more abundant in the Campanian section. Rare specimens occur in the Santonian of Umzamba, although they were not recorded by Dingle (1969) as a separate species in his original description of the fauna.

A length/height scattergram (Fig. 15) effectively separates the three important species of *Brachycythere* found in the Richards Bay/Umzamba areas. *B. sicarius,* whilst having approximately the same length/height ratio as *B. longicaudata,* its closest relative, is a smaller species.

Range

Santonian to Campanian II.

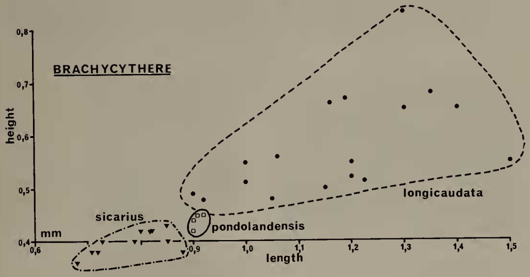

Fig. 15. Scattergram of length v. height for adults of species of *Brachycythere* in BH9 Richards Bay.

Family **Trachyleberididae** Sylvester-Bradley, 1948

Unicapella gen. nov.

Type species

Unicapella sacsi sp. nov.

Derivation of name

To commemorate the 150th anniversary of the founding of the University of Cape Town in 1829: *Uni . . . Cap . . . + ella.*

Diagnosis

A blind, reticulate Trachyleberid with a prominent SCT and spinose/nodose dorsal and ventral margins.

Remarks

Unicapella belongs to a group of recently-described deep water (>1 000 m) genera which includes *Abyssocythere*, *Paleoabyssocythere* and *Atlanticythere* (Benson 1971, 1977). Apparently living in water depths of no more than 500 m, *Unicapella* possibly forms a link between the deep-water forms and their shallow-water ancestors. The group seems to have arisen in the Upper Cretaceous, with its main centre of development in the South Atlantic/South-western Indian Ocean areas.

Unicapella is closest to *Paleoabyssocythere*, which is first recorded from the Campanian of the Brazilian continental margin (Benson 1977), but it differs in ornamentation (*Paleoabyssocythere* is foveolate, not reticulate, and has a massive anterior marginal rim), in size (*Unicapella* is typically less than three-quarters the length of *Paleoabyssocythere*), and hingement (*Unicapella* is holamphidont, *Paleoabyssocythere* is lobodont).

At the type locality (Richards Bay borehole) the new genus (2 spp) is restricted to Campanian II strata, but at least one other species occurs in Maastrichtian sediments farther north (personal unpublished data).

Unicapella sacsi sp. nov.

Fig. 16A–G

Derivation of name

To commemorate the 150th anniversary of the founding of the South African College Schools (SACS) in 1829, from which developed the University of Cape Town.

Holotype

SAM–K5610, RV, BH–9, 88,39 m, Richards Bay, Campanian II

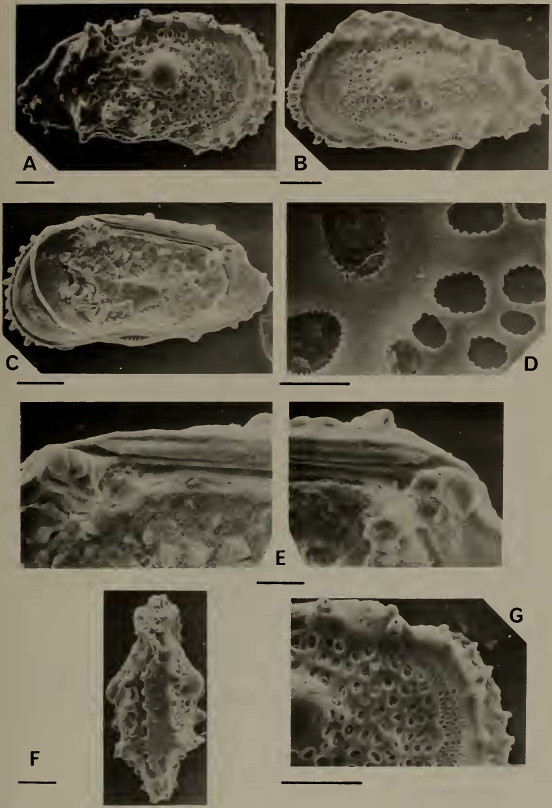

Fig. 16. *Unicapella sacsi* gen. et sp. nov. A. Holotype, SAM–K5610, BH9 88,39 m, RV. B. SAM–K5611, BH9 87,0 m, LV. C. SAM–K5612, BH9 87,0 m, internal RV. D. Holotype, SAM–K5610, BH9 88,39 m, detail ornamentation anterior part RV. E. SAM–K5612, BH9 87,0 m hinge RV. F. SAM–K5613, BH9 87,0 m, dorsal view, carapace. G. Holotype, SAM–K5610, BH9 88,39 m, detail anterior part RV.

Scale bars: D = 10μ, E = 30μ, others = 100μ.

Paratypes

SAM–K5611, LV, BH–9, 87,00 m, Richards Bay, Campanian II
SAM–K5612, RV, BH–9, 87,00 m, Richards Bay, Campanian II
SAM–K5613, Carapace, BH–9, 87,00 m, Richards Bay, Campanian II

Dimensions

	length mm	height mm	width mm
K5610	0,60	0,33	
K5611	0,59	0,31	
K5612	0,52	0,27	
K5613	0,55		0,27

Diagnosis

Species with large, domed SCT and fine surface reticulation.

Description

External features. In lateral view, spinose, symmetrically rounded AM, and asymmetrically acuminate PM. DM straight, with prominent anterior cardinal angles that are notched in the RV, and have a projecting 'ear' in the LV. Surface reticulate and spinose. Several short, large, perforate spines lie along the DM, and an ill-defined ventrolateral clava. Large bullae occur in posterodorsal and posteroventral positions. The SCT is large, bulbous hemispherical and smooth, and forms the widest part of the valve in dorsal view. Valve surface finely reticulate with a few conjunctive pustules, particularly behind the SCT. The depressed anterior area is coarsely reticulate with delicate secondary reticulation. Secondary reticulation also developed in the posterior part of the LV. Fossa muri are finely crenulate, both in primary and secondary reticulation.

Internal features. Hinge amphidont with a narrow terminally widening groove above the ME in RV. In RV, ATE subdivided, PTE smooth or weakly subdivided. MS not seen. MA wide with twelve long, slender, straight anterior, and eight posterior MPC.

Remarks

U. sacsi is close to *Paleoabyssocythere cretacea* Benson, 1977. In addition to differing in aspects related to generic status, *Unicapella sacsi* has less massive spines and bullae and a less symmetric anterior outline. The known range of *P. cretacea* is Santonian/Campanian.

Range

Campanian II.

Unicapella reticulata sp. nov.

Fig. 17A–B

Derivation of name

Reference to coarsely reticulate ornamentation.

Holotype

SAM–K5614, RV, BH–9, 88,76 m, Richards Bay, Campanian II.

Dimensions

	length mm	height mm
K5614	0,65	0,32

Diagnosis

Coarsely reticulate species with spinose muri.

Description

External features. In lateral view, spinose, rounded AM and acuminate PM. DM straight, sloping downwards posteriorly. VM slightly convex. Stout spines

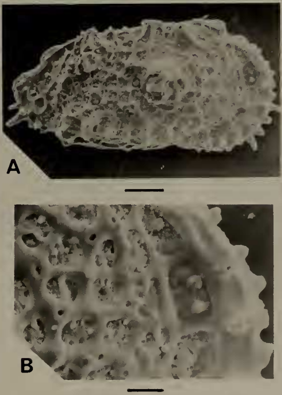

Fig. 17. *Unicapella reticulata* gen. et sp. nov.
A. Holotype, SAM–K5614, BH9 88,76 m, RV.
B. Holotype, SAM–K5614, BH9 88,76 m, detail anterior part RV.
Scale bars: B = 30μ, A = 100μ.

occur along the DM and on a well-defined ventrolateral clava. Large spinose bullae occur in posterodorsal and posteroventral positions. Large, reticulate SCT. Surface coarsely reticulate, with polygonal fossae with small disjunctive and conjunctive spines and pores, and inward pointing mural spines. Depressed anterior area contains very large fossae. There is a marked step at the anterior cardinal angle. Only RV were available for study and no internal features were seen.

Remarks

Despite the limited amount of material available, the distinction between *U. reticulata* and *U. sacsi* can be confidently made: the SCT are reticulate and smooth, respectively; and surface reticulation is coarse and spinose in the former, and fine with crenulated muri in the latter. *U. reticulata* shows some similarities to species allocated to the family Pennyellidae by Neale (1975), with species of both *Agulhasina* and *Pennyella* having spinose muri and reticulate sub-central areas.

U. reticulata is very rare in the Richards Bay borehole (three valves).

Range

Campanian II.

Genus *Cythereis* Jones, 1849

Cythereis transkeiensis Dingle, 1969

Fig. 18A

Cythereis ?ornatissima Reuss, 1846 var. *reticulata* Jones & Hinde, 1890, Chapman, 1904: 234 (no illustration).
Cythereis transkeiensis Dingle, 1969: 377–378, fig. 8.

Three poorly-preserved specimens of *C. transkeiensis* were found in the basal sample (159 m) of the Richards Bay borehole. In contrast, this species occurs in small numbers (*c.* 5%) throughout the Santonian part of the sequence at Umzamba that was examined by Dingle (1969). MS are recorded for the first time and show a typical *Cythereis* arrangement of four posterior, and one U-shape frontal scar.

Range

Santonian.

Cythereis klingeri sp. nov.

Figs 18B–F, 19A–F

Derivation of name

In honour of Dr H. C. Klinger for his recent contributions to knowledge of the stratigraphy and palaeontology of the Cretaceous rocks of Zululand.

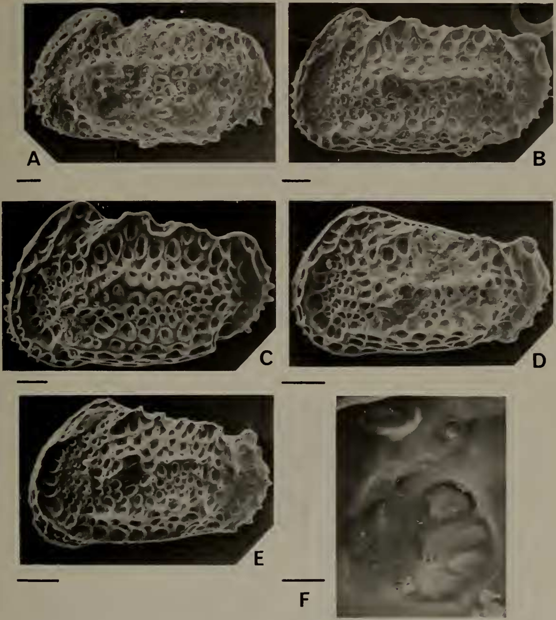

Fig. 18. *Cythereis*. A. *C. transkeiensis* Dingle, 1969, SAM-K5615, BH9 158,0 m, LV. B. *C. klingeri* sp. nov. SAM-K5622, BH9 157,0 m, LV. C. *C. klingeri* sp. nov. SAM-K5623, BH9 124,0 m, LV. D. *C. klingeri* sp. nov. SAM-K5624, BH9 118,22 m, LV. E. *C. klingeri* sp. nov. SAM-K5621, BH9 115,9 m, LV. F. *C. klingeri* sp. nov. SAM-K5618, BH9 82,03 m, muscle scars, RV.

Scale bars: F = 30μ, others = 100μ.

Holotype

SAM–K5616, RV, BH–9, 82,03 m, Richards Bay, Campanian II

Paratypes

SAM–K5617, LV, BH–9, 82,03 m, Richards Bay, Campanian II
SAM–K5618, RV, BH–9, 82,03 m, Richards Bay, Campanian II
SAM–K5619, LV, BH–9, 157,0 m, Richards Bay, Santonian
SAM–K5620, RV, BH–9, 157,0 m, Richards Bay, Santonian
SAM–K5621, LV, BH–9, 115,9 m, Richards Bay, Santonian
SAM–K5622, LV, BH–9, 157,0 m, Richards Bay, Santonian
SAM–K5623, LV, BH–9, 124,0 m, Richards Bay, Santonian
SAM–K5624, LV, BH–9, 118,22 m, Richards Bay, Santonian

Dimensions

	length mm	height mm
K5616	0,78	0,40
K5617	0,79	0,44
K5618	0,80	0,42
K5619	0,74	0,41
K5620	0,75	0,38
K5621	0,58	0,33
K5622	0,83	0,46
K5623	0,75	0,45
K5624	0,58	0,32

Diagnosis

Reticulate species with a prominent, flared, dorsolateral ridge.

Description

External features. In lateral view, AM rounded, DM and VM nearly straight, outline tapering posteriorly. Anterior cardinal angle is prominent, particularly in the LV where it projects well above the dorsal margin. Lateral surface bears three longitudinal ridges which are not interconnected and do not project to the AM. The dorsal ridge is deflected anteromedianly, is flared, and is subdivided about midlength, particularly in the LV. Weakly developed SCT, across which median ridge is deflected anteroventrally. Whole surface strongly reticulate, with ovate to rounded fossae and numerous mural pore cones.

Internal features. Holamphidont hinge. In RV, ATE consists of a dentate, weakly subdivided peg with a thumb-like posterior projection, PTE is a massive, smooth tooth, with an anterior depression to accommodate a projection of the LV ME. Anterior socket of LV is flanked by two large teeth: one at the end of the ME and the other anterior of it. The posterior part of the LV ME is stepped. MS set in a shallow depression and consist of four posterior scars and a hook-shaped frontal scar. There is a prominent fulchral point. MA moderately wide with twelve anterior and six posterior MPC.

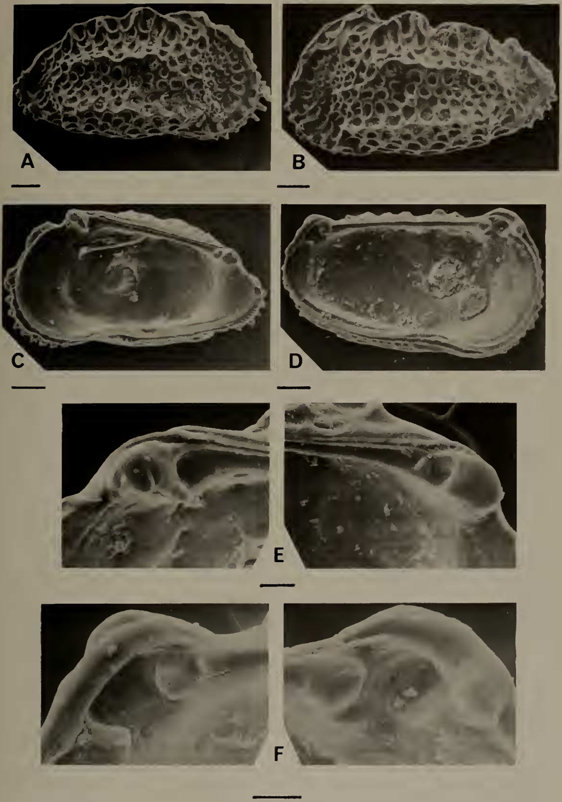

Fig. 19. *Cythereis klingeri* sp. nov. A. Holotype, SAM–K5616, BH9 82,03 m, RV. B. SAM–K5617, BH9 82,03 m, LV. C. SAM–K5618, BH9 82,03 m, internal RV. D. SAM–K5619, BH9 157,0 m, internal LV. E. SAM–K5620, BH9 157,0 m, hinge RV. F. SAM–K5619, BH9 157,0 m, hinge LV.

Scale bars: E–F = 30μ, others = 100μ.

Remarks

Exterior architecture of *C. klingeri* resembles that of *C. transkeiensis*, but differs in being more strongly reticulate, in having a flared dorsal ridge, a tapering posterior outline, and in details of hinge and MS. In the upper part of the Santonian *C. klingeri* is the dominant ostracod (up to 46 % of the population) in what is thought to have been a quiet, shallow-water environment. A good deal of intra-specific variation is displayed in strength of reticulation and prominence of the lateral ridges.

Range

Santonian to Campanian II.

Genus *Haughtonileberis* Dingle, 1969

This genus was created to accommodate local forms that are closely related to the *Dumontina/Curfsina/Hazelina* Complex, but which differ consistently in details of outline, ornamentation, hingement and marginal areas.

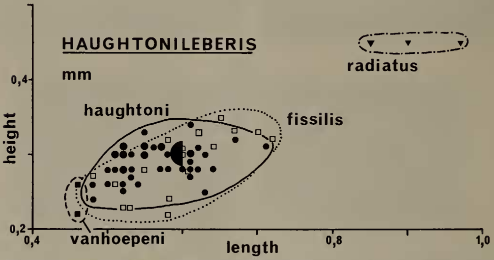

Fig. 20. Scattergram of length v. height for adults of species of *Haughtonileberis* in southern Africa.

Four species have been assigned to *Haughtonileberis* to date, all from southern Africa (a fifth remains to be described): three from the Santonian/Campanian at Umzamba/Richards Bay (*H. haughtoni*, *H. fissilis*, *H. vanhoepeni*), and one from the Eocene of the JC–1 borehole offshore Natal (*H. radiatus*). *H. haughtoni* and *H. fissilis* are well represented in the Santonian to Campanian rocks of the Richards Bay borehole, but both species show a good deal of intra-specific variation, possibly environmentally influenced. *H. vanhoepeni* is rarer (up to 15%) and is confined to Campanian II rocks.

The opportunity is taken here to supplement the original descriptions of *H. haughtoni* and *H. fissilis* with SEM pictures.

Figure 20 shows a scattergram of length/height ratios of the four species of *Haughtonileberis* so far described.

Haughtonileberis haughtoni Dingle, 1969

Fig. 21A–E.

Haughtonileberis haughtoni Dingle, 1969: 372–373, fig. 15.

Two morphotypes of this species have been recognized both at Umzamba and Richards Bay: an elongate form which ranges across the Santonian/Campanian boundary and occurs throughout most of the borehole, and a squatter variety which is confined to the Santonian (shallower water) strata. In the squat variety the dorsolateral ridge tends to be foreshortened, and the median ridge wide throughout its length. In contrast, in some of the more elongate forms the posterior part of the median ridge is reduced to a narrow rib. The holotype appears to be an intermediate form.

H. haughtoni is one of the most important species in the Richards Bay borehole, and it is particularly abundant in the Santonian sequence (assemblage 2) where it reaches 55 per cent and is typically >30 per cent. Its numbers decline sharply in the more open water environments of assemblages 3 and 4 (10–15%) and the species disappears just after the establishment of the deep-water assemblage 5.

Range

Santonian to Campanian II.

Haughtonileberis fissilis Dingle, 1969

Fig. 22A–B

Haughtonileberis fissilis Dingle, 1969: 374–375, fig. 16. Dingle, 1976: 59, fig. 3(48).

H. fissilis occurs sporadically throughout the Richards Bay borehole, and is most abundant (up to 19%) in the Campanian I, moderate-water depth environments. It is recorded from only four horizons in the Santonian section (top assemblage 1, and assemblage 2), where it reaches 14 per cent. On this evidence it would appear that *H. fissilis* favoured somewhat deeper water than its close relative *H. haughtoni*.

As with *H. haughtoni*, *H. fissilis* is known to occur in two morphotypes: a slim finely reticulate type, which is very rare in the Richards Bay borehole, and a squatter, more coarsely reticulate variety. The latter variety has not been found in the Umzamba rocks, where *H. fissilis* is a minor component of the ostracod fauna (<10%).

Range

Santonian to Campanian II.

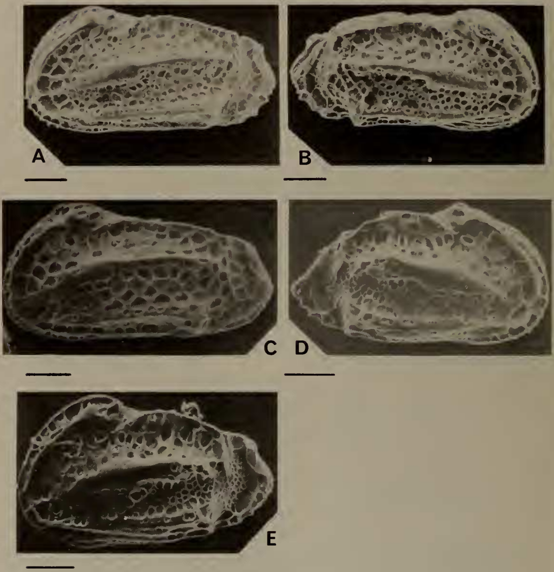

Fig. 21. *Haughtonileberis haughtoni* Dingle, 1969. A. SAM–K5625, BH9 157,0 m, elongate variety, LV. B. SAM–K5626, BH9 157,0 m, elongate variety, RV. C. SAM–K5627, BH9 92,27 m, elongate variety, LV. D. SAM–K5628, BH9 120,22 m, squat variety, RV. E. SAM–K5629, BH9 120,22 m, squat variety, LV.

Scale bars all 100μ.

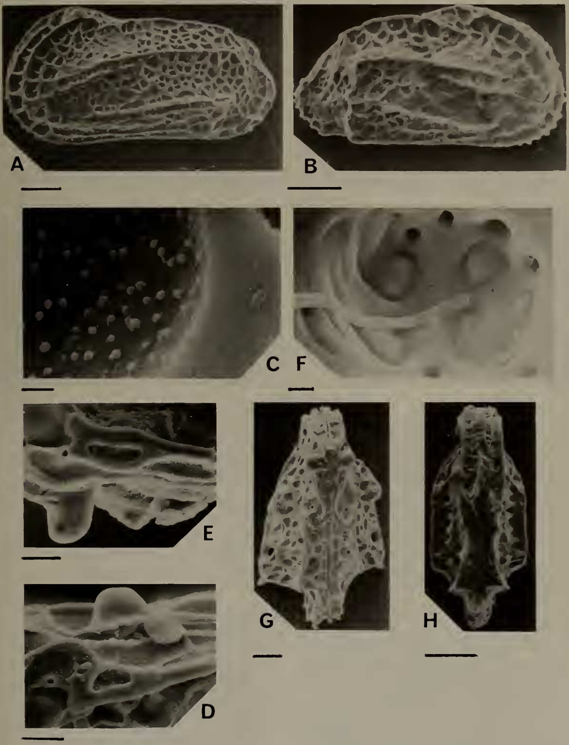

Fig. 22. A. *Haughtonileberis fissilis* Dingle, 1969, SAM–K5630, BH9 115,19 m, LV. B. *Haughtonileberis fissilis* Dingle, 1969, SAM–K5631, BH9 100,0 m, RV. C. *Hermanites kennedyi* sp. nov. SAM–K5638, BH9 88,39 m, papillate solum, RV. D. *Hermanites kennedyi* sp. nov. SAM–K5642, BH9 88,5 m, ATE dorsal view, LV. E. *Hermanites kennedyi* sp. nov. SAM–K5643, BH9 88,39 m, ATE dorsal view, RV. F. *Hermanites kennedyi* sp. nov. SAM–K5639, BH9 88,39 m, muscle scars, LV. G. *Hermanites kennedyi* sp. nov. SAM–K5641, BH9 88,76 m, dorsal view, carapace. H. *Haughtonileberis vanhoepeni* sp. nov. SAM–K5636, BH9 106,0 m, dorsal view, carapace.

Scale bars: C = 3μ, F = 10μ, D–E = 30μ, others = 100μ.

Haughtonileberis vanhoepeni sp. nov.

Figs 22H, 23A–F

Derivation of name

In honour of Dr E. C. N. van Hoepen for his studies of Zululand Cretaceous ammonites.

Holotype

SAM–K5632, RV, BH–9, 100,00 m, Richards Bay, Campanian I.

Paratypes

SAM–K5633, RV, BH–9, 92,27 m, Richards Bay, Campanian I
SAM–K5634, RV, BH–9, 106,00 m, Richards Bay, Campanian I
SAM–K5635, LV, BH–9, 106,00 m, Richards Bay, Campanian I
SAM–K5636, Carapace, BH–9, 106,00 m, Richards Bay, Campanian I

Dimensions

	length mm	height mm	width mm
K5632	0,46	0,22	
K5633	0,46	0,26	
K5634	0,41	0,21	
K5635	0,41	0,23	
K5636	0,41		0,19

Diagnosis

Small species with an inclined median rib which is joined to the ventrolateral rib by a loop.

Description

External features. Small species. In lateral view, AM broadly and asymmetrically rounded, PM bluntly pointed. VM straight, DM slopes posteriorly. Surface bears three narrow longitudinal ribs: dorsal rib is slightly curved, projects beyond the DM and is strongly deflected medianly at its posterior end where it forms a prominent posterior cardinal angle; median rib inclined, projects anterior of the SCT, but does not join the anterior rim, curves ventrally at its posterior end to join the strongly inclined ventrolateral rib which runs from the anteroventral corner of the valve when it joins the anterior rim. Small, prominent eye spots lie on the anterior rim at the cardinal angles in both valves. Intercostal areas smooth, with a few small ridges and minor reticulation. Several prominent pustules. In dorsal view the posterior ends of the dorsal ribs appear as small ears.

Internal features. Hinge holamphidont. In RV ATE is a stepped tooth, and PTE a small, undivided smooth tooth. In LV ME is a smooth bar which thickens terminally with a downward inclined tooth at its anterior end. MA

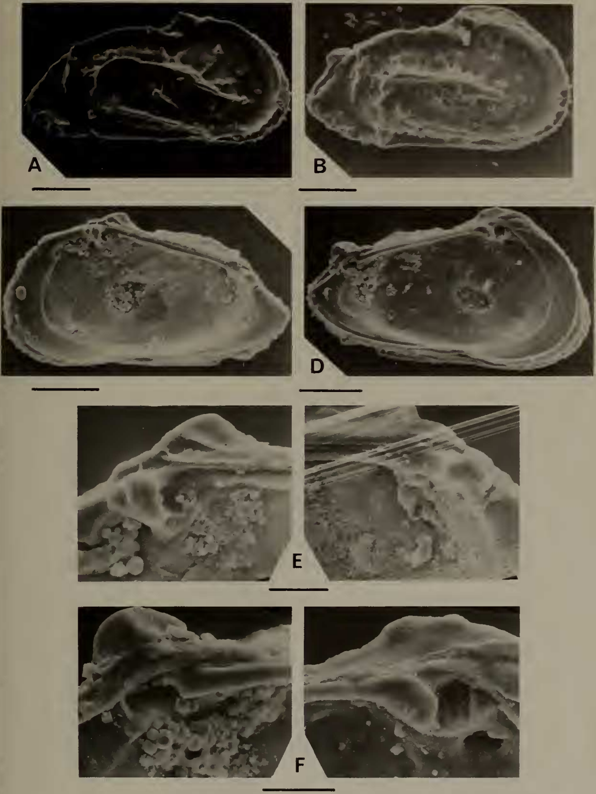

Fig. 23. *Haughtonileberis vanhoepeni* sp. nov. A. Holotype, SAM–K5632, BH9 100,0 m, RV. B. SAM–K5633, BH9 92,22 m, RV. C. SAM–K5634, BH9 106,0 m, internal RV. D. SAM–K5635, BH9 106,0 m, internal LV. E. SAM–K5634, BH9 106,0 m, hinge RV. F. SAM–K5635, BH9 106,0 m, hinge LV.

Scale bars: E–F = 30μ, others = 100μ.

moderately wide with small vestibules. MPC short and straight: 20–25 anteriorly, *c.* 10 posteriorly. MS not clearly seen.

Remarks

Differs from the two other Upper Cretaceous species of the genus in ridge disposition, intercostal ornamentation, and in being smaller. In ornamentation and rib arrangement, *H. vanhoepeni* is intermediate between the more elongate varieties of *H. fissilis* and an unnamed species from the Campanian at False Bay.

Preservation of this species is typically very good—specimens are clean and semi-translucent to translucent, and mostly in the form of carapaces. *H. vanhoepeni* is restricted to assemblage 4 where it locally reaches 15 per cent of the population.

Range

Uppermost Santonian to Campanian I.

Genus *Hermanites* Puri, 1955

Hermanites kennedyi sp. nov.

Figs 22C–G, 24A–F

Derivation of name

In honour of Dr W. J. Kennedy for his contribution to the palaeontology and stratigraphy of the Cretaceous rocks of south-east Africa.

Holotype

SAM–K5637, LV, BH–9, 82,03 m, Richards Bay, Campanian II

Paratypes

SAM–K5638, RV, BH–9, 88,39 m, Richards Bay, Campanian II
SAM–K5639, LV, BH–9, 88,39 m, Richards Bay, Campanian II
SAM–K5640, RV, BH–9, 88,76 m, Richards Bay, Campanian II
SAM–K5641, Carapace, BH–9, 88,76 m, Richards Bay, Campanian II
SAM–K5642, LV, BH–9, 88,5 m, Richards Bay, Campanian II
SAM–K5643, RV, BH–9, 88,39 m, Richards Bay, Campanian II

Dimensions

	length mm	height mm	width mm
K5637	0,71	0,38	
K5638	0,72	0,37	
K5639	0,71	0,36	
K5640	0,72	0,38	
K5641	0,74		0,43
K5642	0,75		0,20
K5643	0,74		0,20

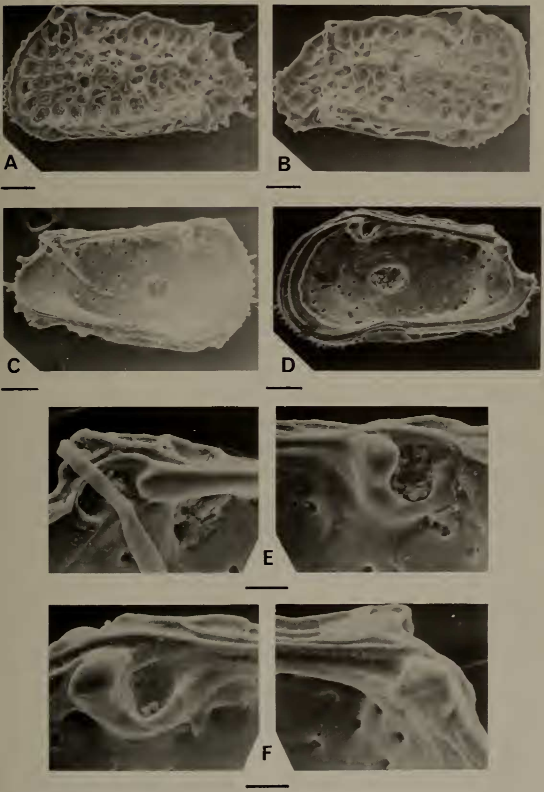

Fig. 24. *Hermanites kennedyi* sp. nov. A. Holotype, SAM–K5637, BH9 82,03 m, LV. B. SAM–K5638, BH9 88,39 m, RV. C. SAM–K5639, BH9 88,39 m, internal LV. D. SAM–K5640, BH9 88,76 m, internal RV. E. SAM–K5639, BH9 88,39 m, hinge LV. F. SAM–K5640, BH9 88,76 m, hinge RV.

Scale bars: E–F = 30μ, others = 100μ.

Diagnosis

Species with prominent alae and a ventrally inclined posterior outline in the RV lateral view.

Description

External features. In lateral view, AM weakly spinose and symmetrically rounded in RV, slightly asymmetric in LV, DM and VM converge slightly posteriorly. PM coarsely spinose, bluntly acuminate, ventrally inclined in RV. There are three longitudinal lateral ribs, the dorsal and ventral of which flare posteriorly, the latter prominently. The median ridge is short and lies posterior to, and detached from the prominent SCT. There is a prominent eye spot which is not attached to the strong AM rim. Surface coarsely reticulate with occasional conjunctive pustules. Fossae are polygonal, with rounded corners and papillate sola. In dorsal view there is a prominent projection of the LV valve margin across the hingeline anterior of the eye spot.

Internal features. Hinge holamphidont, with smooth peg-like terminal elements in the RV, the PTE being weakly subdivided. Posterior groove of the RV ME is seen to be weakly crenulate in well-preserved specimens. MS consist of four posterior spots, the dorsal one of which is a deformed V-shape, and two anterior scars—an asymmetric U and a rounded dorsal scar. MA very narrow with twenty-three anterior and eight posterior MPC.

Remarks

H. kennedyi resembles *H. sagitta* from the Santonian-Campanian of Australia (Bate 1972). They both possess an arrow-head outline in dorsal view, and flared ventral and dorsal ribs, but *H. kennedyi* differs in possessing a short median lateral rib, is more spinose posteriorly, has a different posterior outline in RV, has a finely crenulate ME in the hinge, and possesses a more complex MS pattern. *H. volans* from the Santonian of Australia (Neale 1975) possesses prominent alae, but differs from the new species in not having a prominent dorsal rib, nor a median rib behind the SCT.

In the Richards Bay borehole, *H. kennedyi* is restricted to the Campanian section where it locally forms an important element in the fauna (*c.* 16%). It appears to have a preference for the deeper-water environment.

Range

Campanian II.

Genus *Oertliella* Pokorny, 1964

Oertliella pennata sp. nov.

Fig. 26A–E

Acanthocythere? aff. *A. horridula* (Bosquet, 1854), Dingle, 1969: 378–380, fig. 19.

Derivation of name

From the Latin *penna* (feather), reference to feather-like posterodorsal spine in LV.

Holotype

SAM–K5644, LV, BH–9, 115,9 m, Richards Bay, Santonian.

Paratypes

SAM–K5645, RV, BH–9, 115,9 m, Richards Bay, Santonian.
SAM–K5646, LV, BH–9, 120,22 m, Richards Bay, Santonian.

Dimensions

	length mm	height mm
K5644	0,68	0,36
K5645	0,71	0,34
K5646	0,75	0,38

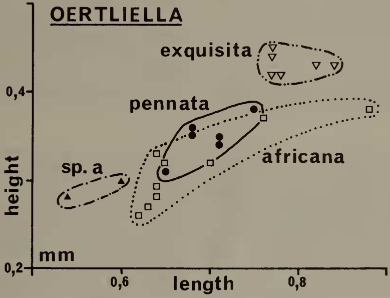

Fig. 25. Scattergram of length v. height for adults of *Oertliella pennata, O. africana, O.* sp. A and *O. exquisita* Bate.

Diagnosis

Elongate species with a large, serrated spine at the posterior cardinal angle of the LV.

Description

External features. In lateral view, elongate quadrate outline with spinose, rounded AM and bluntly acuminate PM. DM and VM straight, tapering slightly posteriorly. Surface coarsely reticulate with numerous conjunctive and disjunctive spines. Fossae are polygonal (3 and 4 sided) and the main muri radiate from the prominent SCT, which has a large verrucose spine. The most

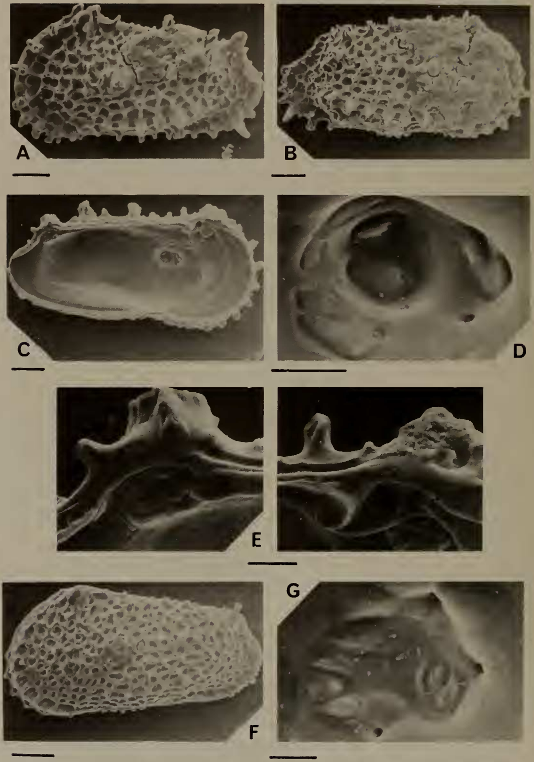

Fig. 26. *Oertliella.* A. *O. pennata* sp. nov., holotype, SAM–K5644, BH9 115,9 m, LV. B. *O. pennata* sp. nov. SAM–K5645, BH9 115,9 m, RV. C. *O. pennata*, sp. nov. SAM–K5646, BH9 120,22 m, internal LV. D. *O. pennata* sp. nov. SAM–K5646, BH9 120,22 m, muscle scars, LV. E. *O. pennata* sp. nov. SAM–K5646, BH9 120,22 m, hinge, LV. F. *O.* sp. A, SAM–K5647, BH9 115,9 m, LV. G. *O. africana* sp. nov. SAM–K5650, BH9 82,03 m, muscle scars, LV.

Scale bars: D–E, G = 30μ, others = 100μ.

prominent spines lie along the DM, a posteriorly upswinging ventrolateral clava, and at the antero- and posteroventral corners of the valve. The spine at the posterodorsal angle of the LV is particularly prominent—it is flattened and serrated at its distal end, giving it a feather-like appearance. Eye spot is large, hemispherical, situated at the anterior cardinal angle.

Internal features. Hinge holamphidont. MS situated in and on the outer edge of a prominent pit. Four posterior scars lie in a line, the lower two are wedge-shaped and lie close together, the 3rd scar is rounded, and lies in the centre of the pit, whilst the dorsal scar is small and rounded. A further small rounded impression lies posterior of this group. Anterior scar is V-shaped, but partially subdivided. MA narrow with twenty paired, short, straight, anterior and twelve posterior MPC.

Remarks

O. pennata differs from its relation *O. africana*, also from the Richards Bay borehole, in details of ornamentation, hinge, and in possessing a prominent eye spot. It is closest to *O. exquisita* from the Campanian of western Australia (Bate 1972) but the two can be separated on subtle differences in shape, reticulation of the posterior parts of the valves, the 'feather-like' spine of *pennata*, the generally smaller size of the African species, as well as its greater length/height ratio:

Average values: RV—1,81 *exquisita* 2,05 *pennata*
LV—1,80 *exquisita* 1,98 *pennata*

O. pennata occurs in small numbers (up to 15%) throughout assemblages 3 and 4, and it is found at one horizon in assemblage 2.

Range

Santonian to Campanian II.

Oertliella africana sp. nov.

Figs 26G, 27A–E

Derivation of name

Location of type.

Holotype

SAM–K5648, LV, BH–9, 82,03 m, Richards Bay, Campanian II

Paratypes

SAM–K5649, RV, BH–9, 87,0 m, Richards Bay, Campanian II
SAM–K5650, LV, BH–9, 82,03 m, Richards Bay, Campanian II
SAM–K5651, RV, BH–9, 97,5 m, Richards Bay, Campanian I

Dimensions

	length mm	height mm
K5648	0,76	0,37
K5649	0,63	0,27
K5650	0,88	0,38
K5651	0,65	0,32

Diagnosis

An elongate species with prominent posteroventral and dorsal spines, and a weak eye spot.

Description

External features. In lateral view, elongate quadrate. AM rounded, PM bluntly acuminate—both coarsely spinose, particularly the posteroventral area, which carries a long pointed spine. DM straight, VM slightly convex in the LV. Surface reticulate with small, rounded fossae. Muri not symmetrically arranged. SCT not well developed, often only represented by a smooth, slightly raised area. DM carries a few large, flared, blade-like spines, particularly in the LV, where the anterior cardinal angle is surmounted by a very prominent spine. There is an upswinging ventrolateral clava with several verrucose spines. The eye spot is weakly developed: in the LV it is usually present below the anterior cardinal angle, and in the RV it is frequently not distinguishable.

Internal features. Hinge paramphidont, with a large projection in front of the ATE in the LV. MS consists of four elongate posterior scars and a V-shaped anterior scar set in a shallow depression. The anterior scar has three raised portions, suggesting incipient subdivision. MA narrow, with fifteen short straight anterior and seven posterior MPC.

Remarks

Its closest relative is *O. pennata* from which it differs in possessing a weak eye spot, rounded fossae, lacking a radiating pattern to its reticulation, and having only a weak SCT. The two species also have different hinge structures and slightly different length/height ratios (Fig. 25).

O. africana is most abundant (up to 4 %) in assemblage 5 (quiet deep water).

Range

Campanian I and II.

Oertliella sp. A

Fig. 26F

Remarks

Three specimens resembling *O. africana*, but lacking the coarse spines. Fossae are more quadrate and the valve outline somewhat plumper.

Range

Campanian I and II.

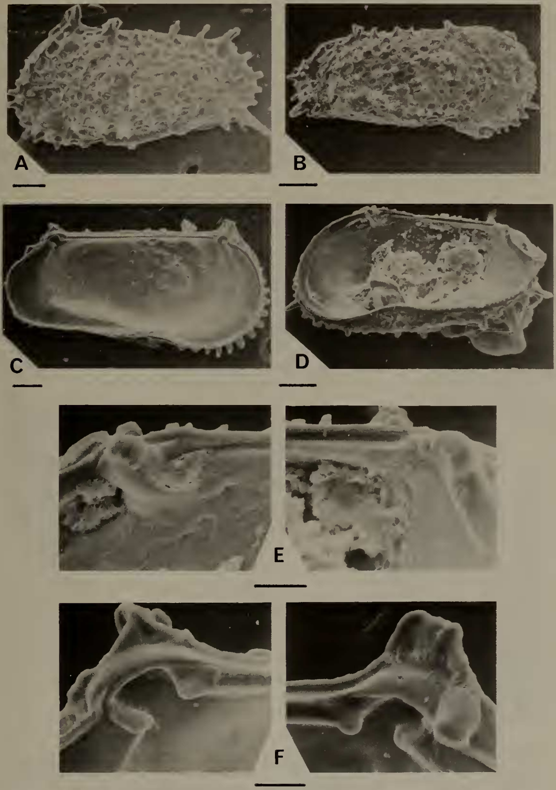

Fig. 27. *Oertliella africana* sp. nov. A. Holotype, SAM–K5648, BH9 82,03 m, LV. B. SAM–K5649, BH9 87,0 m, RV. C. SAM–K5650, BH9 82,03 m, internal LV. D. SAM–K5651, BH9 97,5 m, internal RV. E. SAM–K5651, BH9 97,5 m, hinge RV. F. SAM–K5650, BH9 82,03 m, hinge LV.

Scale bars: E–F = 30μ, others = 100μ.

Genus *Trachyleberis* Brady, 1898

Two species are herein assigned to the genus on the basis of their shape, hinge, and ornamentation. Whilst both are somewhat less spinose than the genotype, their features are commensurate with some recent interpretations of the genus (e.g. Neale 1975). The lack of distinct posteromedian spine alignment suggests that neither belongs in the genus *Actinocythereis*, and whilst both (*T. minima* sp. nov. in particular) are very similar exteriorly to the genotype of *Matronella* Damotte, 1974, the apparently smooth ATE and PTE of the Zululand specimens, and the fact that MS were not seen, precludes positive assignment to this genus.

Trachyleberis zululandensis sp. nov.

Fig. 28A–C

Derivation of name

Locality of type.

Holotype

SAM–K5652, LV, BH–9, 82,03 m, Richards Bay, Campanian II

Paratype

SAM–K5653, RV, BH–9, 82,03 m, Richards Bay, Campanian II

Dimensions

	length mm	height mm
K5652	0,82	0,40
K5653	0,78	0,36

Diagnosis

A blind species with a triangular lateral outline, and a prominent SCT.

Description

External features. Valve laterally compressed. In lateral view, spinose, rounded AM, triangular PM. DM and VM straight, converging posteriorly to produce a triangular lateral outline. Surface ornamented with stout spines, many of which are perforate. Castellated spines occur along the DM, and in the median region. There is a large spinose SCT. Under low magnification the valve surface appears smooth, but under high magnification is seen to be finely reticulated with hair-like muri.

Internal features. Hinge holamphidont. MS not seen. MA narrow, with at least 20 anterior MPC.

Remarks

T. zululandensis is similar to *T. schizospinosa* Dingle from the Maastrichtian of the Agulhas Bank (Dingle 1971*b*) and *T. raynerae* Neale from the Santonian of Australia (Neale 1975). It differs from the latter in not possessing an eye spot,

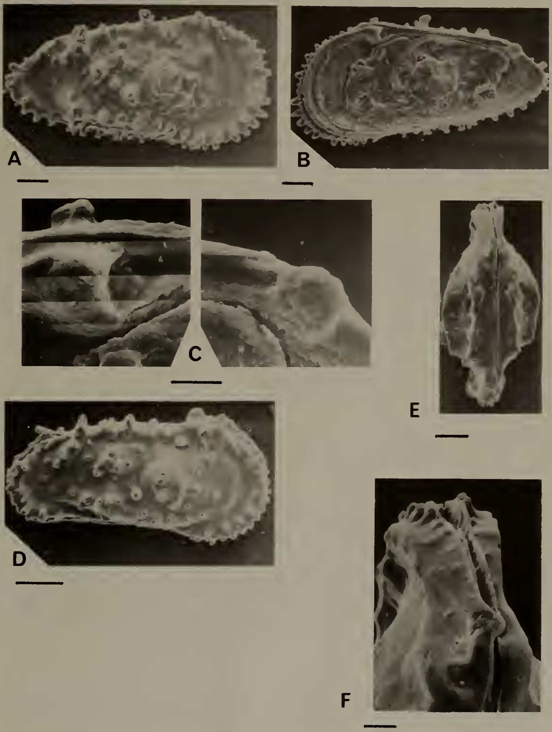

Fig. 28. A. *Trachyleberis zululandensis* sp. nov., holotype, SAM–K5652, BH9 82,03 m, RV. B. *Trachyleberis zululandensis* sp. nov. SAM–K5653, BH9 82,03 m, internal RV. C. *Trachyleberis zululandensis* sp. nov. SAM–K5653, BH9 82,03 m, hinge RV. D. *Trachyleberis minima* sp. nov., holotype, SAM–K5654, BH9 110,0 m, RV. E. *Rayneria nealei* sp. nov. SAM–K5656, BH9 115,9 m, dorsal view, carapace. F. *Rayneria nealei* sp. nov. SAM–K5656, BH9 115,9 m, detail anterior end, dorsal view, carapace.

Scale bars: C, F = 30µ, others = 100µ.

in having less elongate spines, but in possessing a more prominent SCT. Its closest relative is *T. schizospinosa*, but this species is plumper, more quadrate in outline, and possesses small eye spots.

T. zululandensis is rare in the Richards Bay borehole (only two samples contain it, up to 3%) and it is confined to assemblages 4 and 5. Its slightly greater abundance in sample 82,03 and its blindness suggest that it preferred deep-water environments.

Range

Campanian I and II.

Trachyleberis minima sp. nov.

Fig. 28D

Derivation of name

Its small size.

Holotype

SAM–K5654, RV, BH–9, 110,00 m, Richards Bay

Dimensions

	length mm	height mm
K5654	0,54	0,25

Diagnosis

Quadrate species with a concave ventral outline in lateral view.

Description

External features. In lateral view quadrate with rounded AM and a bluntly rounded PM, which is directed slightly posteroventrally. Both end margins bear numerous small, short spines. DM is straight, VM is concave—posterior to line of maximum height. The lateral surface has several short, small spines which are confined to the DM, a short curved ventrolateral clava, and the median area (on the prominent SCT, and in a cluster behind the SCT). Interspinal areas are smooth, with numerous small, low, circular pustules. There is a large globular eye spot at the anterior cardinal angle. No internal features seen.

Remarks

Placement of this small spiney species is provisional because no internal features were seen. The VM concavity and downturned PM make it easily recognized. *T. minima* is rare in the Richards Bay borehole in one sample only (at 3%) in Campanian I.

Range

Campanian I.

Genus *Rayneria* Neale, 1975

Rayneria nealei sp. nov.

Figs 28E–F, 29A–E, 30G

Cythereis ?quadrilatera (Römer) Chapman, 1923: 5, pl.1(5).

Derivation of name

In honour of Prof. J. W. Neale who erected the genus.

Holotype

SAM–K5652, RV, BH–9, 139,8 m, Richards Bay, Santonian

Paratypes

SAM–K5653, LV, BH–9, 106,00 m, Richards Bay, Campanian I
SAM–K5654, RV, BH–9, 115,19 m, Richards Bay, Campanian I
SAM–K5655, LV, BH–9, 139,8 m, Richards Bay, Santonian
SAM–K5656, Carapace, BH–9, 115,9 m, Richards Bay, Santonian
SAM–K5657, RV, BH–9, 118,22 m, Richards Bay, Santonian

Dimensions

	length mm	height mm	width mm
K5652	0,53	0,27	
K5653	0,50	0,24	
K5654	0,54	0,28	
K5655	0,53	0,28	
K5656	0,57		0,32
K5657	0,51		0,12

Diagnosis

Small, blind species with small SCT.

Description

External features. In lateral view, small, subquadrate ostracod. AM bears short spines, symmetrically rounded in RV, extended ventrally in LV. PM rounded in LV, asymmetric in RV, bears several stout spines posteroventrally. DM hidden, outline is convex. VM concave. Surface bears three short longitudinal ridges: the dorsal ridge is curved and slightly flared; the median ridge is short, commences just anterior of the small, elongate SCT, and has a posteroventral deflection; the ventral ridge is convex. Intercostal areas heavily calcified, with small raised pustules and scattered rounded fossae. Cardinal angles rounded in LV, but in the RV the anterior cardinal angle is weakly developed. No eye spots. There is a prominent ear-like overlap by the LV just in front of anterior cardinal angle in dorsal view.

Internal features. Hinge holamphidont but with a stepped and posteriorly-elongated ATE in RV. There is a small additional tooth in front of ATE in LV.

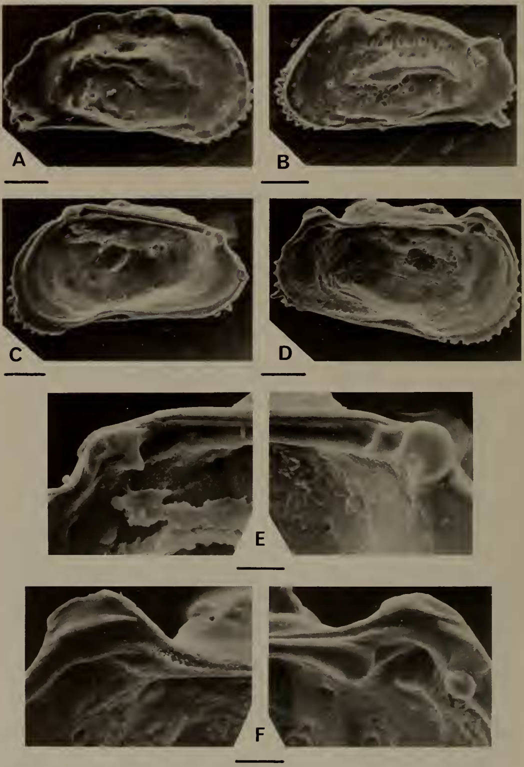

Fig. 29. *Rayneria nealei* sp. nov. A. Holotype, SAM–K5652, BH9 139,8 m, RV. B. SAM–K5653, BH9 106,0 m, LV. C. SAM–K5654, BH9 115,19 m, internal RV. D. SAM–K5655, BH9 139,8 m, internal LV. E. SAM–K5654, BH9 115,19 m, hinge RV. F. SAM–K5655, BH9 139,8 m, hinge LV.

Scale bars: E–F = 30μ, others = 100μ.

MS not clearly seen, but they lie in a deep central pit. MA narrow, no vestibules, up to 18 anterior and 8 posterior MPC.

Remarks

Rayneria nealei is similar to *Rayneria ginginensis* Neale from the Santonian of Australia in its surface ornamentation, but differs by not having eye spots and by possessing a small SCT.

The possession of eyespot was considered by Neale (1975: 59) to be a generic characteristic, but it is not thought to be desirable to create a new genus on this criterion alone, where Neale's is otherwise mono-specific.

R. nealei is a sporadic component of assemblages 1, 2 and 3, and occurs in small numbers in the early range of assemblage 4. It is never common and only locally accounts for >10 per cent of the total fauna.

Range

Santonian to lower Campanian I.

Genus *Gibberleberis* Dingle, 1969

Gibberleberis africanus Dingle, 1969

Figs 30A–D, 31A

Gibberleberis africanus Dingle, 1969: 370–377, fig. 17.

This species was first described from the Santonian of Umzamba cliff section, where it occurs sparingly (up to 3%). In the Richards Bay borehole it is also restricted to Santonian rocks and again occurs in small numbers (up to 15%). It is most common in the uppermost Santonian rocks (assemblage 3).

Some of the new material is very well preserved and SEM pictures are included to supplement the original description. MS (previously not recorded) are rather complex, with 5 posterior scars and two anterior scars. The edges of individual scars are serrated. Topotypic specimens are more heavily calcified than individuals from Richards Bay.

Range

Santonian.

Gibberleberis elongata sp. nov.

Figs 30, 31B

Derivation of name

Elongate shape in lateral view.

Holotype

SAM–K5660, RV, BH–9, 124,0 m, Richards Bay, Santonian

Paratype

SAM–K5661, RV, BH–9, 124,0 m, Richards Bay, Santonian

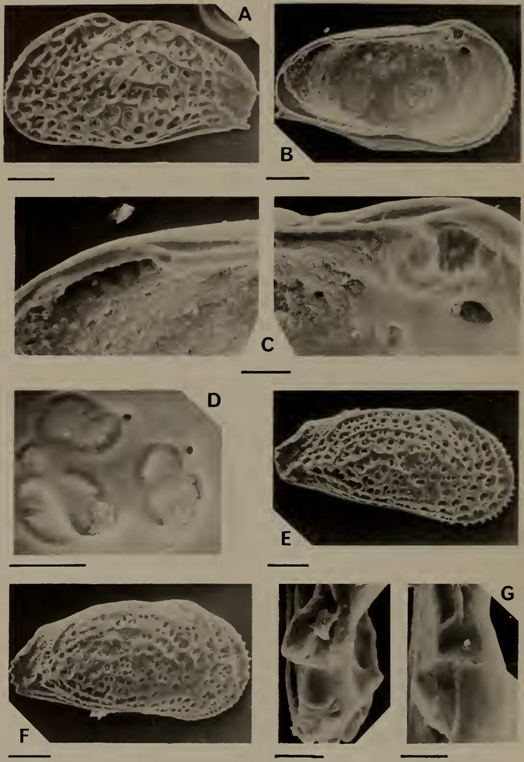

Fig. 30. A. *Gibberleberis africanus* Dingle, 1969, SAM–K5658, BH9 118,22 m, LV. B. *Gibberleberis africanus* Dingle, 1969, SAM–K5659, BH9 118,22 m, internal LV. C. *Gibberleberis africanus* Dingle, 1969, SAM–K5659, BH9 118,22 m, hinge LV. D. *Gibberleberis africanus* Dingle 1969, SAM–K5659, BH9 118,22 m, muscle scars, LV. E. *Gibberleberis elongata* sp. nov. Holotype, SAM–K5660, BH9 124,0 m, RV. F. *Gibberleberis elongata* sp. nov. SAM–K5661, BH9 124,0 m, RV. G. *Rayneria nealei* sp. nov. SAM–K5657, BH9 118,22 m, ATE and PTE of hinge, dorsal view, RV.

Scale bars: C–D, G = 30μ, others = 100μ.

Dimensions

	length mm	height mm
K5660	0,6	0,25
K5661	0,6	0,30

Diagnosis

Elongate, finely reticulate species, with straight ventral outline in lateral view.

Description

External features. In lateral view, AM symmetrically rounded, PM asymmetrically acuminate. Dorsal outline broadly humped, ventral outline straight, producing a posteroventral elongation. Surface finely reticulate with, in the upper part of the valve, main muri running longitudinally, parallel to an arched, low, dorsal rib. This accentuates the humped appearance. Valves slightly swollen ventrally, particularly posterior of mid-length. SCT represented by a smooth area in the reticulate pattern. Eyespot elongate and low.

No internal features seen.

Remarks

G. elongata and *G. africanus* are very closely related. In addition to differences in lateral outline, the most obvious point of reference is the difference in disposition of the reticulation ribs (Fig. 31). In *G. elongata* the muri on the dorsolateral area are more numerous, concentrically arranged, and less curved, and in the anterior area are larger.

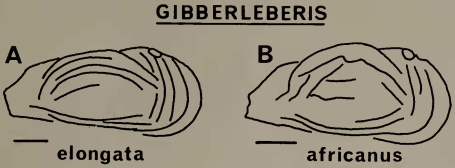

Fig. 31. Sketches of *Gibberleberis* species showing main rib patterns. A. *G. elongata* sp. nov., holotype, SAM–K5660, BH9 124,0 m, RV. B. *G. africanus* Dingle, 1969, BH9 140,0 m, RV.
Scale bars 100μ.

G. elongata is rare in the Richards Bay borehole (six valves only recorded from three horizons), and occurs in both Santonian and Campanian rocks.

Range

Santonian to Campanian II.

DISCUSSION

The ostracods in BH–9 are all benthic types, and thirty-six species belonging to seventeen genera have been recognized. There are several distinctive changes in the composition of the ostracod populations along the length of the borehole, and it is convenient to examine these from two viewpoints: palaeoecological and biostratigraphical.

PALAEOECOLOGY

The regional Cretaceous geology in south Zululand, in combination with evidence to be presented below, indicates that the sedimentary history of the borehole is of a marine transgression across a granitic surface followed by a progressive increase in water depth. Temporary returns to shallower water and/or higher energy environments at intervals up the borehole may represent minor regressive episodes. Changes in the geometry of the depositional area caused by the progressive increase in water depth would have constantly modified ecological factors, such as current strengths (e.g. tidal, wave-driven, and oceanographic), salinity, food supply, and water temperature. Because such factors would have determined the make-up of the ostracod faunas, it ought to be possible, by their study, to monitor the changes in the sedimentary environment. Whilst, at this stage, the influences of the more subtle factors cannot be recognized, it is possible to express the overall sedimentary history in terms of alterations in such generalized factors as water depth, overall energy of the environment, and access to open water (i.e. oceanic) regimes. This can be done by the recognition of ostracod assemblages, which can be assigned to particular sedimentary environments on the basis of species distribution and overall population trends.

Ostracod assemblages 1–5

The vertical distribution of each ostracod species is shown in Table 1, and various statistical data on species and population trends are shown in Figure 32. Five ostracod types numerically dominate the faunas (>20% of total population), either singly or in combinations, and in successive zones up the borehole these are (maximum % based on three point means in brackets): *Brachycythere longicaudata* (51%), *B. longicaudata* (40%) with *Haughtonileberis haughtoni* (56%), *Cythereis klingeri* (45%), *Bairdoppilata andersoni* (36%), and *B. andersoni* (41%), with various species of *Cytherella* (32%). The level at which the dominance of these types or combinations changes is usually clear cut (1–2 m wide) and coincides with important changes in numbers and presence/absence of secondary and minor taxa, as well as alterations in diversity, similarity and overall size of the entire ostracod populations (Fig. 32, Tables 2–3). Only the change over from the *B. longicaudata*/*H. haughtoni* to the *C. klingeri*-dominated faunas is transitional and takes place with a good deal of fluctuation in all parameters over a distance of about 4 m in the borehole. The distinctive ostracod populations in these zones have been designated 'ostracod assemblages' 1 to 5 and are shown in Figure 32 and Tables 2–3. Most of the secondary and minor taxa occur in more than one assemblage (although several are confined to only two), but six species are restricted to only one. It is possible therefore to characterize each assemblage in terms of its dominant types (>20%) with, in three cases, additional specialized, but relatively rare, taxa. These associations are summarized in Table 3. At a more general level, reference to Table 1 shows

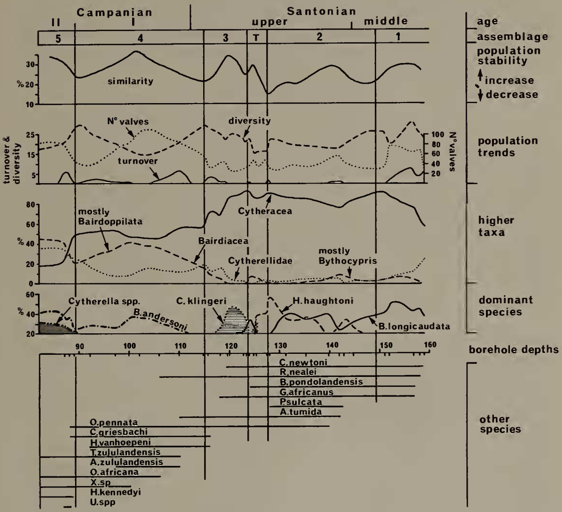

Fig. 32. Variations in the ostracod faunas of BH9, Richards Bay. Discontinuities in the various curves have been used to delimit ostracod assemblages 1 to 5 which are described in detail in the text and Tables 2–3. Population stability has been measured by variations in the similarity index between sample points up the borehole (ticks on the column marked borehole depth). Population turnover is a measure of the number of new appearances and extinctions in each sample, and the population diversity is calculated as number of species per hundred specimens. Note that for most of the borehole there is an inverse relationship between population diversity and the total number of valves per sample i.e. largest populations tend to be the least diverse. The only large deviation from this trend is in the lower part of ostracod assemblage I. These relationships may in part, however, be influenced by the statistical bias of dealing with small numbers of specimens. Note that in all cases, percentage of species and higher taxa quoted in this figure and in the text are based on three-point running mean values.

that assemblages 1, 2 and 3 are closely related both in terms of individual minor and secondary species (e.g. *Cytherelloidea newtoni*, *Brachycythere pondolandensis*, and *Gibberleberis africanus*) and higher taxa (Cytheracean dominated, >60%), and that similarly, assemblages 4 and 5 have many characteristics in common (nine species do not extend below 115,9 m, and the faunas are mainly Bairdiacean/Cytherellid types).

It is clear that the overriding driving force behind these population alterations was environmental change because such alterations were sudden but yet did not lead to the extinction of the dominant species. Some of the appearances and extinctions in the minor taxa may be phylogenetic, but the close corre-

TABLE 2

Make-up of faunal assemblages.

	1	2	T	3	4	5
Dominant (>20%)	*B. longicaudata*	*B. longicaudata*	———			
		H. haughtoni	———			
			———	*C. klingeri*		
					B. andersoni	*B. andersoni*
						Cytherella spp.
Secondary (5–15%)	*H. haughtoni*			*H. haughtani*	*H. haughtani*	
	C. klingeri	*C. klingeri*				
				B. langicaudata	*B. longicaudata*	
				P. umzambaensis		
					Cytherella spp.	
					B. richardsbayensis	
						*H. kennedyi**
Minor (generally <5% but occurs in >1 sample)	*C. newtoni*	*C. newtoni*	———	*C. newtoni*		
	B. richardsbayensis	*B. richardsbayensis*				
	P. umzambaensis	*P. umzambaensis*	———		*P. umzambaensis*	*P. umzambaensis*
	P. zululandensis	*P. zululandensis*			*P. zululandensis*	*P. zululandensis*
	R. nealei	*R. nealei*	———	*R. nealei*	*R. nealei*	
	B. sicarius	*B. sicarius*	———		*B. sicarius*	*B. sicarius*
	G. africanus	*G. africanus*	———	*G. africanus*		
	B. pondolandensis	*B. pandalandensis*	———			
		H. fissilis			*H. fissilis*	*H. fissilis*
		A. tumida	———		*A. tumida*	
		*P. sulcata**				
				O. pennata	*O. pennata*	*O. pennata*
					C. umzambaensis	*C. umzambaensis*
					C. griesbachi	*C. griesbachi*
					O. africana	*O. africana*
					*A. zululandensis**	
					*H. vanhoepeni**	
						Unicapella spp.
						X. sp.
rare and sporadic (<5% single occurrences)	*C. umzambaensis*			*C. umzambaensis*		
	C. transkeiensis					
	H. fissilis					
		G. elongata	———			*G. elongata*
		O. pennata				
				O. sp. A	*O. sp. A*	*O. sp. A*
				C. griesbachi		
				B. sicarius		
					T. zululandensis	*T. zululandensis*
					*T. minima**	
					X. sp.	
					*C. contorta**	

* – restricted to one ostracod assemblage
T – transitional

spondence between maxima in population turnover and assemblage boundaries, where the assemblages are defined by dominant taxa present (Fig. 32) suggests that most are local, ecologically-related events.

Sedimentary environments

Various lines of evidence can be used to deduce the palaeosedimentary environments from the character of the ostracod assemblages 1 to 5. Overall conclusions are summarized in Table 3. The two most clear-cut cases are assemblages 1 and 5. In the former, the dominant species is *B. longicaudata*, which appears in the earliest sediments immediately above the basement surface (sample 159 m). There is a rapid build-up in total size of population from an estimated 3 600 adults/m^2 at the base to a maximum of about 10 000 adults/m^2 higher up, coeval with a steady influx of new species colonizing the newly-created marine environment. The latter trend is seen on Figure 32 as a high turnover rate (dominantly appearances). Once established, the fauna has a high diversity ($>20\%$) and an average similarity index value of $>25\%$ (which indicates a moderately stable population). Corroded and blackened valves near the base of the borehole, together with the absence of *Bairdoppilata* and low numbers of *Cytherella* suggest that ostracod assemblage 1 inhabited a shallow water, high energy environment with restricted access to the open ocean. Sedimentation rates were probably fairly high, but cannot be quantified. On this evidence, *B. longicaudata* can be regarded as a 'hardy' species and its temporary resurgence at intervals high up in the borehole (especially in the upper part of assemblage 4 and between 123 and 125,5 m) may indicate temporary returns to somewhat higher energy environments.

Assemblage 5 consists of a mixed Bairdiacea/Cytherellidae population with relatively rare ($<20\%$) Cytheracean types. The combination of *Bairdoppilata* with abundant *Cytherella* in modern environments appears to indicate moderately deep-water (outer continental shelf) environments (e.g. Rosenfeld & Bein 1978). A similar conclusion for assemblage 5 is supported by the presence of four blind Cytheracean species (*Unicapella* (2 spp), *Oertliella africana*, and *Trachyleberis zululandensis*), as well as *Xestoleberis* sp. An interesting and significant member of this assemblage is the unusual genus *Unicapella*, whose closest relative is *Paleoabyssocythere* from the Campanian of the northern Rio Grande Rise (DSDP site 21) (Benson 1977). The latter genus was the forerunner of the psychrospheric Cainozoic genus *Abyssocythere*. Benson (1977) reckons that *Paleoabyssocythere cretacea* lived at depths of at least 1 000 m. Assemblage 5 certainly does not suggest depths as great as this, but does indicate that the environment was 'oceanic' in the sense that there were free connections to the palaeo South Atlantic. The relative abundance of the architecturally complex *Hermanites kennedyi*, as well as the low faunal diversity (<20 species/100 valves), but high population densities (10 400 adults/m^2) and stabilities ($>30\%$) indicate low energy, deep (perhaps between 200 and 500 m) conditions. One surprising absentee is the typically deep-water 'marker' *Krithe*.

TABLE 3

Suggested palaeoenvironments and marker ostracods (i.e. dominant ostracods or ones restricted to specific facies). All are terrigenous-dominated sedimentary environments.

Assemblage	1	2	3	4	5
Palaeoenvironment	Shallow water, high energy, restricted circulation	Shallow water, low energy, restricted circulation (<100 m)	Shallow, low energy open water, (<100 m)	Moderate depth, low energy, open water (?100–200 m)	Deep, low energy, open water, (outer cont. shelf) (?200–500 m)
diagnostic ostracods >20%	*B. longicaudata*	*B. longicaudata* *H. haughtoni*	*C. klingeri*	*B. andersoni*	*B. andersoni*
specialized types	none	*P. sulcata*	none	*A. zululandensis* *H. vanhoepeni* *T. minima* *C. contorta*	*H. kennedyi* *Unicapella* spp.
other characteristics high taxa	Cytheraceans 60–90%	Cytheraceans 80–90%	Cytheraceans 70–90%	Cytheraceans 50–60% Bairdiacea 30–40% Cytherellidae >10%.	Cytheraceans 20–40% Bairdiacea 30–45% Cytherellidae >30%
faunal diversity (No. species/ 100 specimens)	>20% (high)	~20% (medium)	>20% (high)	<20% (low)	<20% (low)
population stability (average similarity indices)	(>25%) medium	(>20%) low	(>25%) medium	(<25%) medium	(>30%) high
estimated typical adult population–individual adults per square metre $\left(\frac{\text{No. of Valves}}{2}/\text{m}^2\right)$	10 000	5 000	5 000	12 000	10 400

Assemblages 2, 3 and 4 represent environments intermediate to 1 and 5. Abundant *Bairdoppilata*, the increasing importance of *Cytherella*, and the appearance of blind forms suggest that assemblage 4 marks the onset of moderately deep-water conditions and probably represents a midshelf (100–200 m depth) environment. The increasing specialization of the fauna in assemblage 4 is indicated by the low population diversity ($<20\%$) coupled with a large population density (12 000 adults/m^2).

Through assemblages 2 and 3, the importance of *B. longicaudata* is in progressive, if erratic decline, and in assemblage 3 the Cytheracean component as a whole declines sharply (about 90% at the base to 60% at the top). Deep-water elements are largely absent and the population stability is only low to medium as the faunas constantly adjusted to deepening water and lower energy environments. Both assemblages 2 and 3 suggest shallow water, low energy environments, and the low population diversity in assemblage 2 ($\sim 20\%$) probably indicates somewhat restricted conditions. Population stability (as measured by averaging the similarity indices) is especially low at about 128 m in the borehole, above which, for a short distance (about 3 m), rapid fluctuations in *C. klingeri*/*H. haughtoni*/*B. longicaudata* numbers indicate a period of population instability probably related to fluctuating current strengths caused by sea-level movements (? minor regressions). Similar, but less pronounced events, occur at the boundaries between assemblages 3 and 4, and 4 and 5. Table 3 summarizes the conclusions on palaeoenvironments up the borehole.

Finally, the trends exhibited in the ostracod population as it adjusted to changing environmental conditions over a period of about 5 m.y. can be graphically expressed in Figure 33A. Here, total Cytheracea–Cytherellidae–Bairdiacea/Cypridacea components are plotted on a triangular diagram. Each of the ostracod assemblages occupies a well-defined field although areas of assemblages 1, 2 and 3 overlap. An interesting feature of this diagram is that it emphasizes the trend followed by the initial, colonizing fauna (assemblage 1) as it rapidly develops towards Cytheracean dominance, which persists, and is more firmly established, through the duration of assemblage 2. The field occupied by assemblage 3 partially overlaps with that of assemblage 1, but can be distinguished from it by the presence of several moderate water depth elements in the Cytheracean component (e.g. *O. pennata*, *A. tumida*). Fields for assemblages 4 and 5 are well separated, with the latter showing a progressive trend towards the Bairdiacea/Cypridacea–Cytherellidae base line as the water depth increases. Despite the closeness of parts of fields 4 and 5 to field 1, distinction can easily be made by the make-up of their respective Bairdiacea/Cypridacea components: to the 'north' of the divide this component is a *Paracypris* plus subordinate *Bythocypris* population, whereas to the 'south' it is a *Bairdoppilata* plus subordinate *Paracypris* and *Bythocypris* population.

Translating these population fields into palaeoenvironments Figure 33B is generated. At present, its applicability to other areas has not been tested and it can only be considered relevant to the BH–9 borehole.

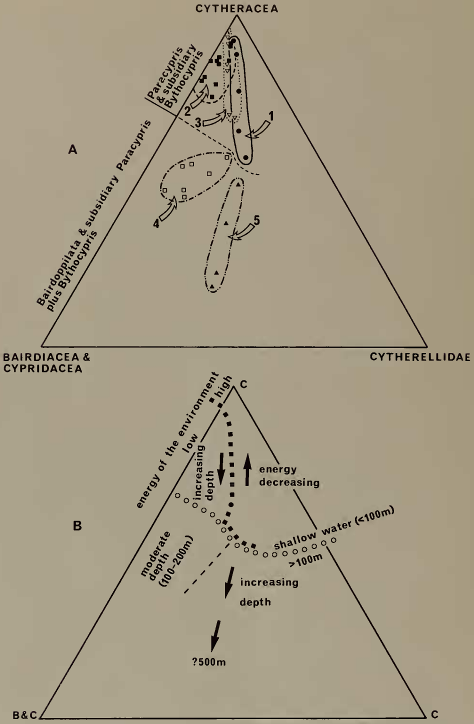

Fig. 33. A. Triangular plot of ostracod populations of all samples in the BH9 borehole in terms of percentage of Cytheracea, Bairdiacea plus Cypridacea, and Cytherellidae. The fields of ostracod assemblage 1 to 5 are outlined. B. Variations in the ostracod populations (expressed in terms of Cytheracea, Bairdiacea plus Cypridacea, and Cytherellidae) with changing sedimentary environments in the BH9 borehole. Arrows indicate direction of change up the borehole based on movement within the fields of the various assemblages shown in Figure 33A. In the elongate fields of assemblages 1 and 5 these trends are actually followed in successive samples up the borehole. The square dot line separates high and low energy environments, whilst the open circle line separates shallow and moderate/deep-water environments.

BIOSTRATIGRAPHY

The main stratigraphic horizons recognized by Klinger & Kennedy (1977, fig. 12) in BH–9 are the Santonian/Campanian, and Campanian I/II boundaries: the former is marked by the appearance of *Vendegiesiella* cf. *V. spinosa* and *V. trituberculata*, and the latter by the appearance of *Baculites vanhoepeni*. These horizons, together with a suggested subdivision of the Santonian based on a comparison with Madagascar ammonite faunas, are shown in Figure 32. Both the Santonian/Campanian, and Campanian I/II boundaries fall very close to the boundaries between ostracod assemblages 3 and 4, and 4 and 5, respectively, which raises the possibility that the appearance of the different ammonite species might also be facies-controlled and not strictly phylogenetic. Further work on the Santonian and Campanian ostracods of Zululand will clarify this issue.

Notwithstanding this possibility, it is desirable to see if any phylogenetic trends can be recognized in the ostracod faunas against the dominating patterns of environmental control. Certainly at this stage it is not possible to say, for instance, that the appearance of *Cytherelloidea griesbachi*, *Haughtonileberis vanhoepeni*, *Trachyleberis zululandensis* or *Amphicytherura zululandensis* is diagnostic of the basal Campanian strata throughout south-east Africa. They may turn out to be so, but their apparent environmentally controlled ranges in the borehole leads one to suspect that this is not the case, unless of course they are endemic to the Zululand area and they evolved solely because of environmental stress—in which case they will be restricted to a particular facies. On the other hand, some of the obviously less environmentally-bound species may show phylogenetic relationships that will turn out to be biostratigraphically useful. Amongst them may be *Brachycythere pondolandensis*, *Gibberleberis africanus* and *Cytherelloidea newtoni* (mid-upper Santonian), *Rayneria nealei* (mid-Santonian to Campanian I), *Amphicytherura tumida* (upper Santonian to Campanian II), and *Oertliella pennata* (upper Santonian to Campanian I).

As might be anticipated, ostracods from the lower part of the borehole show very close affinities with the Santonian assemblages from the lower part of the Umzamba cliff section. According to Klinger & Kennedy (1977), the lowest 7 m at Umzamba are a condensed equivalent of the section 159 m–115 m in the Richards Bay borehole, but whilst the ostracod assemblages in the borehole show considerable temporal variations, the four samples studied by Dingle (1969, fig. 21) show little or no significant variation from the base to the top of the Umzamba Santonian sequence. At the latter, *Brachycythere longicaudata* dominates the fauna throughout (>30%) with *Cytherelloidea umzambaensis*, *Haughtonileberis haughtoni* and *Pondoina sulcata* consistently present up to about 10% each. On this evidence, the restriction of *Pondoina sulcata* and *Cythereis transkeiensis* to assemblages 3 and 1, respectively, in the borehole can only be explained by environmental control, whilst a similar restriction of *Oertliella pennata* (originally identified as *Acanthocythereis* aff. *A. horridula* by Dingle (1969)) to the Santonian at Umzamba has no biostratigraphic significance.

TABLE 4

Santonian ostracods at Richards Bay and Umzamba.

	Richards Bay	Umzamba
Cythereis transkeiensis	*	*
C. klingeri	*	*
Cytherelloidea newtoni	*	—
C. umzambaensis	*	*
C. gardeni	?*	*
C. griesbachi	*	—
Brachycythere longicaudata	*	*
B. pondolandensis	*	*
B. rotunda	—	*
B. sicarius	*	*
Paracypris umzambaensis	*	*
P. zululandensis	*	—
Haughtonileberis haughtoni	*	*
H. fissilis	*	*
H. vanhoepeni	*	—
Cytherella spp.	*	*
Rayneria nealei	*	*
Gibberleberis africanus	*	*
G. elongata	*	—
Bairdoppilata andersoni	*	*
Bythocypris richardsbayensis	*	—
Pondoina sulcata	*	*
Amphicytherura tumida	*	*
Oertliella pennata	*	*
O. sp. A.	*	—
Paraphysocythere thompsoni	—	*
Veenia obesa	—	*
?Cnestocythere	—	*

28 types (*Cytherella* spp counted as one), 17 common. Similarity 61%.

Table 4 shows the species identified at both localities and indicates a 61 per cent similarity at the species level. Significant differences include the restriction of several species to either area: to Umzamba *Paraphysocythere thompsoni*, *Brachycythere rotunda* and *Veenia obesa*; to Richards Bay *Gibberleberis elongata*, *Cytherelloidea newtoni*, and the virtual substitution of *Cythereis transkeiensis* by *C. klingeri* in the borehole. In terms of Figure 33B the Umzamba faunas fall within the shallow water high energy environments, with one sample on the border of the field adjacent to a somewhat lower energy environment.

Commentary on the similarity of the Richards Bay ostracods with extra-southern African Santonian/Campanian faunas will be postponed until the ostracods from other outcrops of a similar age in Zululand have been studied.

ACKNOWLEDGEMENTS

The author thanks Dr H. Klinger of the South African Museum for making the borehole samples available, and for helpful discussion on the stratigraphy of Zululand. The borehole material was originally the property of the Geological Survey of South Africa, but has recently been donated to the South African

Museum by the Survey Director Dr W. L. van Wyk. The study was made possible by a University of Cape Town staff research grant for which the author is grateful. Mr G. Lowcock and Dr D. Crawford of the Electron Microscopy Unit at the University of Cape Town are thanked for their help in the SEM photography which was undertaken on the Unit's instruments.

REFERENCES

ALEXANDER, C. I. 1929. Ostracoda of the Cretaceous of north Texas. *Bull. Univ. Texas Bur. econ. Geol.* **2907**: 1–137.

ALEXANDER, C. I. 1933. Shell structure of the ostracode genus *Cytheropteron* and fossil species from the Cretaceous of Texas. *J. Paleont.* **7**: 181–214.

APOSTOLESCU, V. 1961. Contribution à l'étude paléontologique (Ostracodes) et stratigraphique des bassins crétacés et tertiares de l'Afrique occidentale. *Revue Inst. fr. Petrole* **16**: 779–867.

BAIRD, W. 1845. Arrangement of British Entomostraca, with a list of species, particularly noticing those which have as yet been discovered within the bounds of the Club. *Hist. Berwicksh. Nat. Club* **2**: 145–148.

BAIRD, W. 1850. *The natural history of the British Entomostraca:* 1–364, London, Ray Society.

BATE, R. H. 1972. Upper Cretaceous ostracods from the Carnarvon Basin, Western Australia. *Special Papers in Palaeontology* **10**: 1–85.

BENSON, R. H. 1971. A new Cenozoic deep-sea genus, *Abyssocythere* (Crustacea: Ostracoda: Trachyleberididae), with descriptions of five new species. *Smithson. Contrib. Paleobiol.* **7**: 1–25.

BENSON, R. H. 1977. The Cenozoic ostracode faunas of the Sao Paulo Plateau and the Rio Grande Rise (DSDP Leg 39, Sites 356 and 357). *Initial Reports of the Deep Sea Drilling Project* 39: 869–883. Washington: United States Government Printing Office.

BOSQUET, J. 1854. Monographie des crustacés fossiles du terrain Crétacé du Duché Limbourg. *Mémoires de la Commission pour la description de la Carte geologique de la Neerlande* **2**: 53–126.

BRADY, G. S. 1880. Report on ostracoda dredged by H.M.S. *Challenger* during the years 1873–76. *Reports on the scientific results of the voyage of H.M.S. Challenger, Zoology* **1**(3): 1–184.

BRADY, G. S. 1898. On new or imperfectly-known species of ostracoda, chiefly from New Zealand. *Trans. zool. Soc. Lond.* **14**: 429–452.

BUTLER, E. A. & JONES, D. E. 1957. Cretaceous ostracoda of Prothro and Rayburn salt domes Bienville Parish, Louisiana. *Bull. geol. Surv. La.* **32**: 1–65.

CHAPMAN, F. 1898. On ostracoda from the "Cambridge Greensand". *Ann. Mag. nat. Hist.* **3**: 331–346.

CHAPMAN, F. 1904. Foraminifera and ostracoda from the Cretaceous of east Pondoland, South Africa. *Ann. S. Afr. Mus.* **4**: 221–237.

CHAPMAN, F. 1917. Monograph of the Foraminifera and Ostracoda of the Gingin Chalk. *Bull. geol. Surv. West. Aust.* **72**: 1–87.

CHAPMAN, F. 1923. On some foraminifera and ostracoda from the Cretaceous of the Umzamba River, Pondoland. *Trans. geol. Soc. S. Afr.* **26**: 107–118.

CORYELL, H. N., SAMPLE, C. H. & JENNINGS, P. H. 1935. *Bairdoppilata*, a new genus of ostracoda, with two new species. *Am. Mus. Novit.* **777**: 1–5.

DAMOTTE, R. 1974. Un noveau genre d'ostracode de l'Albien du Bassin de Paris: *Matronella* n.g. Importance des empreintes musculaires dans les attributions génériques chez les Trachyleberidinae. *Paleontographica* **146**: 181–189.

DINGLE, R. V. 1969. Upper Senonian ostracods from the coast of Pondoland, South Africa. *Trans. R. Soc. S. Afr.* **38**: 347–385.

DINGLE, R. V. 1971*a*. *Cytherelloidea gardeni* nom. nov. (Ostracoda). *Trans. R. Soc. S. Afr.* **39**: 353.

DINGLE, R. V. 1971*b*. Some Cretaceous ostracodal assemblages from the Agulhas Bank (South African continental margin). *Trans. R. Soc. S. Afr.* 39: 393–418.

Dingle, R. V. 1976. Palaeogene ostracods from the continental shelf off Natal, South Africa. *Trans. R. Soc. S. Afr.* **42**: 35–79.

Dingle, R. V. 1978. South Africa. *In:* Moullade, M. and Nairn, A. E. M. eds. *The Phanerozoic geology of the world II, The Mesozoic* A: 401–434. Amsterdam: Elsevier.

Förster, H. D. 1975. Die geologische Entwicklung von Süd-Mozambique seit der Unterkreide und die Ammoniten-Fauna von Unterkreide und Cenoman. *Geol. Jb.* **12**: 3–324.

Howe, H. V. & Laurencich, L. 1958. *Introduction to the study of Cretaceous Ostracoda.* Baton Rouge: Louisiana State University Press.

Jones, T. R. 1849. *A monograph of the Entomostraca of the Cretaceous Formations of England.* London: Palaeontological Society.

Jones, T. R. 1884. Notes on the Foraminifera and Ostracoda from the deep boring at Richmond *Q. Jl geol. Soc. Lond.* **40**: 766–777.

Jones, T. R. & Hinde, G. J. 1890. *A supplementary monograph of the Cretaceous Entomostraca of England and Ireland.* London: Palaeontographical Society.

Kennedy, W. J. & Klinger, H. C. 1975. Cretaceous faunas from Zululand and Natal, South Africa. Introduction, stratigraphy. *Bull. Br. Mus. nat. Hist.* (Geol.) **25**: 263–315.

Klinger, H. C. & Kennedy, W. J. 1977. Upper Cretaceous ammonites from a borehole near Richards Bay, South Africa. *Ann. S. Afr. Mus.* **72**: 69–107.

Latreille, P. A. 1806. *Genera Crustaceorum et Insectorum* **1**: 1–303. Paris.

Mandelstam, M. I. 1960. *In:* Orlov, Y. A. ed. *Elements of palaeontology.* Vol. **VIII**. Arthropods: 1–515, Moscow, Geological and subsurface prospecting: Scientific and Technical Edition. (In Russian.)

Maud, R. & Orr, W. 1975. Aspects of post-Karroo geology in the Richards Bay area. *Trans. geol. Soc. S. Afr.* **78**: 101–109.

Moore, R. C. *ed.* 1961. *Treatise on invertebrate paleontology. Part Q, Arthropoda* 3. Lawrence: University of Kansas Press.

Müller, G. W. 1894. Die Ostracoden des Golfes von Neapel und der angrenzenden Meeresabschnitte. *Fauna Flora Golf. Neapel* **31**: 1–404.

Neale, J. W. 1975. The ostracod fauna from the Santonian Chalk (Upper Cretaceous) of Gingin, Western Australia. *Special Papers in Palaeontology* **16**: 1–81.

Puri, H. S. 1954. Contribution to the study of the Miocene of the Florida Panhandle. Part III (Ostracoda). *Bull. geol. Surv. Fla.* **3**: 217–309.

Puri, H. S. 1955. *Hermanites*, a new name for *Hermania* Puri 1954. *J. Paleont.* **29**: 558.

Pokorny, V. 1964. *Oertliella* and *Spinicythereis*, new ostracod genera from the Upper Cretaceous. *Vest. ustred. Ust. geol.* **39**: 283–284.

Reuss, A. E. 1846. *Die Versteinerungen der böhmischen Kreide Formation:* **2**: 59–148, Stuttgart; Schweizerbart.

Sars, G. O. 1866. Oversigt af Norges marine ostracoden. *Forh. VidenskSelsk. Krist.* **7**: 1–130.

Sars, G. O. 1888. Nye Bidrag til Kundskaken om Midlehavets Invertebrat fauna 4. Ostracoda Mediterranea. *Arch. Math. Naturv.* **12**: 173–324.

Sars, G. O. 1922–1928. *An account of the Crustacea of Norway* **9**. *Ostracoda*, Parts 1–16: 1–277. Bergen: Bergen Museum.

Rosenfeld, A. & Bein, A. 1978. A preliminary note on recent ostracodes from shelf to rise sediments off Northwest Africa. *Meteor ForschErgebn.* **29**: 14–20.

Sylvester-Bradley, P. C. 1948. The ostracode genus *Cythereis*. *J. Paleont.* **22**: 792–797.

Sylvester-Bradley, P. C. & Benson, R. H. 1971. Terminology for surface features in ornate ostracods. *Lethaia* **4**: 249–286.